PATENT ABSTRACTS OF JAPAN

(11)Publication number : 07-044519
(43)Date of publication of application : 14.02.1995

(51)Int.CI. G06F 15/18
// G06F 9/44

(21)Application number : 05-192564
(22)Date of filing : 03.08.1993

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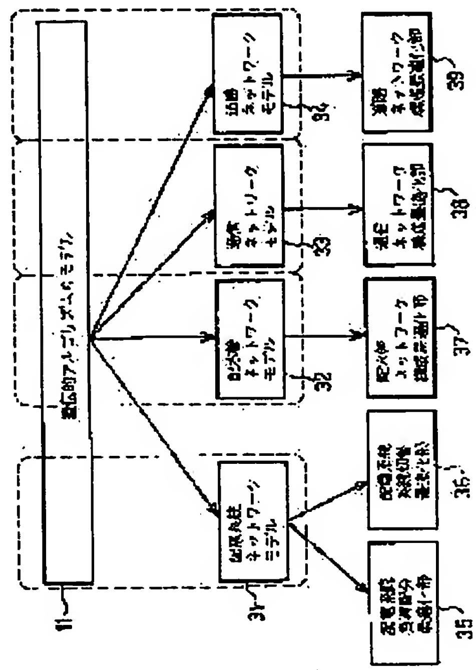
(54) GENETIC ALGORITHM MOUNTING METHOD AND NETWORK OPTIMIZING METHOD USING THE SAME

(57)Abstract:
PURPOSE: To make the generation of the software efficient for application of a genetic algorithm and optimization of a network.
CONSTITUTION: A general-purpose model 11 of a genetic algorithm built up by adopting an object orientation design is combined with models 31-34 of an application object, and the genetic algorithm is layered by a gene template class not including data of the application object and a gene class including the data to manage the interface of both the models in the lump thereby enhancing the independency, and flexible modeling of networks 35-39 such as a distribution system, water supply pipes, a communication network and a road network and the model is flexibly revised and the optimization of the network and the retrieval of a radial network are attained by providing a model of the application object and an evaluation function of the optimization.



LEGAL STATUS

[Date of request for examination] 14.02.2000

[Date of sending the examiner's decision of rejection] 27.05.2003

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's

decision of rejection]
[Date of extinction of right]

CLAIMS

[Claim(s)]
[Claim 1] The genetic algorithm mounting approach which adopts an object oriented design, considers as the hierarchical model which has the gene class which are the gene template class which does not contain at all the data of said object which is going to apply the model of said genetic algorithm, and a subclass containing the data of said object which it is going to apply in the genetic algorithm mounting approach of mounting the genetic algorithm which is the approach of optimizing an object, and is characterized by to combine with the model of said object which is going to apply the genetic algorithm concerned.
[Claim 2] The genetic algorithm mounting approach according to claim 1 which sets a power-distribution-system network as said target which it is going to apply, expresses a node class and the transmission line between each node for the power node and load node which are the component of said power-distribution-system network as a branch class, builds a network to a bottom-up, and is characterized by modeling said power-distribution-system network hierarchical.
[Claim 3] The genetic algorithm mounting approach according to claim 1 which sets a distributing water pipe network as said target which it is going to apply, expresses a branch class and a junction for the distributing water pipe which is the component of said distributing water pipe network as a node class, builds a network to a bottom-up, and is characterized by modeling said distributing water pipe network hierarchical.
[Claim 4] The genetic algorithm mounting approach according to claim 1 which sets a communication network as said target which it is going to apply, expresses a branch class and a communication network node for the communication link transmission line which is the component of said communication network as a node class, builds a network to a bottom-up, and is characterized by modeling said communication network hierarchical.
[Claim 5] The genetic algorithm mounting approach according to claim 1 which sets a road network as said target which it is going to apply, expresses a branch class and a crossing for the road which is the component of said road network as a node class, builds a network to a bottom-up, and is characterized by modeling said road network hierarchical.
[Claim 6] The network optimization approach characterized by performing this [to said power node of said load node / rate] so that the performance index defined based on the delivery capacity of the power source of each power node of said power-distribution-system network model and the capacity of the load node connected to it in the network optimization approach which optimizes the configuration of the power-distribution-system network which mounted the genetic algorithm using the approach of invention indicated to claim 2 may be made into max.
[Claim 7] The network optimization approach characterized by performing system switching of said power-distribution-system network so that the performance index defined based on the capacity of each transmission line of said power-distribution-system network model may be made into min in the network optimization approach which optimizes system switching of the power-distribution-system network which mounted the genetic algorithm using the approach of invention indicated to claim 2.
[Claim 8] The network optimization approach characterized by arranging said distributing water

pipe so that the performance index defined based on the capacity of each distributing water pipe of said distributing water pipe network model may be made into min in the network optimization approach which optimizes the configuration of the distributing water pipe network which mounted the genetic algorithm using the approach of invention indicated to claim 3.

[Claim 9] The network optimization approach characterized by installing said communication link transmission line so that the performance index defined based on the capacity of each communication link transmission line of said communication link network model may be made into min in the network optimization approach which optimizes the configuration of the communication network which mounted the genetic algorithm using the approach of invention indicated to claim 4.

[Claim 10] The network optimization approach characterized by arranging said road so that the performance index defined based on the capacity of each road of said road network model may be made into min in the network optimization approach which optimizes the configuration of the road network which mounted the genetic algorithm using the approach of invention indicated to claim 5.

[Claim 11] The genetic algorithm mounting approach characterized by searching the network of the radial concerned by adding the node which the distance from a node used as the criteria in the network of said radial chose from the inside of an equal node in the genetic algorithm mounting approach which searches the network constituted by the radial and applies a genetic algorithm to the network of said radial.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the network optimization approach using the genetic algorithm mounting approach and its genetic algorithm mounting approach for applying the genetic algorithm which is the approach of optimizing the object of arbitration to that object.
[0002]
[Description of the Prior Art] Drawing 15 is the conceptual diagram showing the genetic algorithm which is the approach of optimizing the object of arbitration shown in "the present condition and the technical problem" (Shigenobu Kobayashi Society of Instrument and Control Engineers society magazine "measurement and control" of volume [32nd] 1 No. 2-9th page 1993 January) of a genetic algorithm. In drawing, 1 is the process of initialization by a certain generation's gene cluster, and 2 is the process of the duplicate which reproduces a gene and forms a next-generation gene cluster. 3 is the process of the decussation which makes a gene a group and replaces the part, and 4 is the process of mutation in which it is exchanged in a part of gene.
[0003] Next, actuation is explained. First, optimization of the object by such genetic algorithm is explained. In a genetic algorithm, the candidate for application which it is going to optimize is expressed by a character string etc., and it considers that it is a gene, and rationalizes about two or more genes. The general procedure of this genetic algorithm consists of the process 1 of initialization shown in drawing 15 , the process 2 of a duplicate, a process 3 of decussation, and a process 4 of mutation. Namely, what expressed a certain generation's initialized gene cluster typically shows a gene by 1 of drawing 15 , and, as for the circle in drawing, the pattern in a circle expresses the phenotype of each gene, respectively. Next, a gene is reproduced in process of [2] a duplicate, and a next-generation gene is formed. It is made for more high things of evaluation to remain on the occasion of the duplicate of this gene. Next, the crossover of a gene is performed in the process 3 of decussation. The retrieval range of a solution is expanded rather than an initial population by the crossover of this gene making a gene a group at random, and exchanging some each other and carrying out like this. Next, the mutation of a gene is generated in process of [4] mutation. This mutation makes it generate by exchanging one character of a gene by a certain low probability, and makes escape from a local solution easy by this. The high gene of evaluation is obtained by repeating such initialization, a duplicate, decussation, and the cycle by each process of mutation.
[0004] Moreover, drawing 16 is the explanatory view showing the model of the conventional power-distribution-system network shown in "the power-distribution-system facility extension plan under which the time of accident was taken into consideration" (binary name outside Hirokazu Nara -115 Institute of Electrical Engineers of Japan study group data power technical study group PE-91 1991 October). In the model of this power-distribution-system network, the substation, the transformer, and the load are expressed as ** branches, such as a feeder, the transmission line, etc. between each node, as a node, respectively. In drawing, for 5, as for a transformer node and 7, a source node and 6 are [a substation node and 8] load nodes, 9 is an establishment feeder and 10 is an established feeder.

[0005] In addition, it was required to build software according to the object applied, when it mounts a genetic algorithm in the network set as the object of such application, and when mounting of said duplicate, decussation, and the heredity operator of mutation was changed, software was remade from the beginning. Moreover, when building the model for [of a genetic algorithm] application, and the model became large-scale, it was hard coming to grasp the configuration as a whole, and was a thing accompanied by difficulty in construction of a large-scale model.
[0006]
[Problem(s) to be Solved by the Invention] Since the conventional genetic algorithm was constituted as mentioned above, it was lacking in versatility, and since flexibility was lacked in the target modeling or the correspondence to model modification in case it is applied to the target network, the creation effectiveness of software was low, and there were troubles, such as following difficulty also on network optimization.
[0007] It was made in order that this invention might cancel the above troubles, and invention according to claim 1 enables construction of the model of the general-purpose high genetic algorithm of reusability, and aims at acquiring the genetic algorithm mounting approach that the increase in efficiency of software creation can be calculated.
[0008] Moreover, invention according to claim 2 to 5 aims at acquiring the genetic algorithm mounting approach which can respond also to modification of a model flexibly while the flexible modeling of the network which is a candidate for application becomes possible.
[0009] Moreover, invention according to claim 6 to 10 aims at acquiring the network optimization approach which can optimize a network easily.
[0010] Moreover, invention according to claim 11 aims at acquiring the genetic algorithm mounting approach in which the increase in efficiency of generation of the initial solution in a genetic algorithm is possible.
[0011]
[Means for Solving the Problem] The genetic algorithm mounting approach concerning invention according to claim 1 combines it with the model for application by adopting an object oriented design as a layered structure which has the gene template class which does not contain the data for application for the model of a genetic algorithm at all, and a gene class containing it.
[0012] Moreover, the genetic algorithm mounting approach concerning invention according to claim 2 expresses the power node of the power-distribution-system network for application, a load node, and the transmission line as a node class or a branch class, and a power-distribution-system network is built to a bottom-up, and it models it hierarchical.
[0013] Moreover, the genetic algorithm mounting approach concerning invention according to claim 3 expresses the distributing water pipe of the distributing water pipe network for application, and a junction as a branch class or a node class, and a distributing water pipe network is built to a bottom-up, and it models it hierarchical.
[0014] Moreover, the genetic algorithm mounting approach concerning invention according to claim 4 expresses the communication link transmission line of the communication network for application, and a communication network node as a branch class or a node class, and a communication network is built to a bottom-up and it models it hierarchical.
[0015] Moreover, the genetic algorithm mounting approach concerning invention according to claim 5 expresses the road of the road network for application, and a crossing as a branch class or a node class, and a road network is built to a bottom-up and it models it hierarchical.
[0016] Moreover, the network optimization approach concerning invention according to claim 6 defines a performance index based on the capacity of the load node connected to the current supply capacity of each of that power node, and it about the power-distribution-system network which mounted the genetic algorithm by the approach according to claim 2, and it performs this [to the power node of a load node / rate] so that it may serve as max.
[0017] Moreover, the network optimization approach concerning invention according to claim 7 defines a performance index based on the capacity of each of that transmission line about the power-distribution-system network which mounted the genetic algorithm by the approach according to claim 2, and it performs system switching of a power-distribution-system network

so that it may serve as min.
[0018] Moreover, the network optimization approach concerning invention according to claim 8 defines a performance index based on the capacity of each of that distributing water pipe about the distributing water pipe network which mounted the genetic algorithm by the approach according to claim 3, and it arranges a distributing water pipe so that it may serve as min.
[0019] Moreover, the network optimization approach concerning invention according to claim 9 defines a performance index based on the capacity of each of that communication link transmission line about the communication network which mounted the genetic algorithm by the approach according to claim 4, and it installs a communication link transmission line so that it may serve as min.
[0020] Moreover, the network optimization approach concerning invention according to claim 10 defines a performance index based on the capacity of each of that road about the road network which mounted the genetic algorithm by the approach according to claim 5, and it arranges a road so that it may serve as min.
[0021] Moreover, the distance from a node used as the criteria in the network constituted by the radial chooses a node at random out of an equal node, and the genetic algorithm mounting approach concerning invention according to claim 11 searches the radial network concerned by adding it to the network.
[0022]
[Function] By adopting an object oriented design and mounting the model of a genetic algorithm, the genetic algorithm mounting approach in invention according to claim 1 is made into the high genetic algorithm of versatility independent of the object which it is going to apply using the gene template class which does not contain the data for application at all, and the gene class containing it, and makes generation of software efficient.
[0023] Moreover, by expressing a node class and the transmission line for the power node and load node which are a component as a branch class, a power-distribution-system network is built to a bottom-up, and the genetic algorithm mounting approach in invention according to claim 2 models it hierarchical.
[0024] Moreover, by expressing a branch class and a junction for the distributing water pipe which is a component as a node class, a distributing water pipe network is built to a bottom-up, and the genetic algorithm application approach in invention according to claim 3 models it hierarchical.
[0025] Moreover, by expressing a branch class and a communication network node for the communication link transmission line which is a component as a node class, a communication network is built to a bottom-up and the genetic algorithm application approach in invention according to claim 4 models it hierarchical.
[0026] Moreover, by expressing a branch class and a crossing for the road which is a component as a node class, a road network is built to a bottom-up and the genetic algorithm application approach in invention according to claim 5 models it hierarchical.
[0027] Moreover, the network optimization approach in invention according to claim 6 optimizes the configuration of the power-distribution-system network which mounted the genetic algorithm using the approach of invention indicated to claim 2 by performing this [to the power node of a load node / rate] so that the performance index defined based on the delivery capacity of the power source of each power node and the capacity of the load node connected to it may serve as max.
[0028] Moreover, the network optimization approach in invention according to claim 7 optimizes system switching of the power-distribution-system network which applied the genetic algorithm by the approach of invention indicated to claim 2 by performing system switching of a power-distribution-system network so that the performance index defined based on the capacity of each transmission line may serve as min.
[0029] Moreover, the network optimization approach in invention according to claim 8 optimizes the configuration of the distributing water pipe network which applied the genetic algorithm by the approach of invention indicated to claim 3 by arranging a distributing water pipe so that the performance index defined based on the capacity of each distributing water pipe may serve as

min.
[0030] Moreover, the network optimization approach in invention according to claim 9 optimizes the configuration of the communication network which applied the genetic algorithm by the approach of invention indicated to claim 4 by installing a communication link transmission line so that the performance index defined based on the capacity of each communication link transmission line may serve as min.
[0031] Moreover, the network optimization approach in invention according to claim 10 optimizes the configuration of the road network which applied the genetic algorithm by the approach of invention indicated to claim 5 by arranging a road so that the performance index defined based on the capacity of each road may serve as min.
[0032] Moreover, the genetic algorithm mounting approach in invention according to claim 11 generates the initial solution in a genetic algorithm efficiently by adding the node which the distance from a node used as the criteria in the network constituted by the radial chose at random out of the equal node to the network, and searching the radial network concerned.
[0033]
[Example]
The example 1 of this invention is explained about drawing below example 1. Drawing 1 is the conceptual diagram showing the genetic algorithm mounting approach by one example of invention according to claim 1. In drawing, 11 is the model of a genetic algorithm and 12 is a model for application with which this genetic algorithm is applied. In addition, a thing required as data for application is only the genotype of a gene in the model 11 of this genetic algorithm, and a thing required of the model 12 for application is only the phenotype of a gene. Therefore, it dissociates as an interface between the model 11 of a genetic algorithm, and the model 12 for application, and they are built.
[0034] Moreover, drawing 2 is the conceptual diagram showing the class hierarchy of a genetic algorithm. In drawing, 13 is a gene template class in the least significant of the genetic algorithm concerned, and 14 is a gene class as a subclass which inherited this gene template class 13. It is the population class which 15 has in the high order of this gene class 14, and has the gene class 14 in a member, and 16 is an application class which is in the high order of this population class 15, and has the population class 15 in a member.
[0035] Next, actuation is explained. In addition, the information for application is not included in the gene template class 13 at all, and a heredity operator is not mounted only by declaration, either. As for the gene class 14, a heredity operator is also mounted here including the information for application. Therefore, if it sees from the class of the hierarchy above the gene class 14, member functions, such as a member and a heredity operator, will not be influenced of the data for application. For example, if the member function which shows the "duplicate" which is one of the heredity operators is set to "reproduce", "reproduce" will be an empty function in the gene template class 13, and actual contents will be described by the gene class 14. In the class above the gene class 14, if the function which shows a "duplicate" is described to be "reproduce", it does not need to be concerned with the candidate for application and it is not necessary to change the model 11 of a genetic algorithm.
[0036] Thus, let the interfaces for application be fewer things by the genetic algorithm mounting approach by this example 1 by using the gene class 14 as abstract data type, and mounting the heredity operator who doubled with the information for application, or it by that subclass.
[0037] Example 2., next the example 2 of this invention are explained about drawing. Drawing 3 is the conceptual diagram showing the class hierarchy of the power-distribution-system network by one example of invention according to claim 2. In drawing, 17 is a node class expressing a power node and a load node, and 18 is a branch class expressing branches, such as the transmission line which connects between nodes. 19 is a graph class used as two or more nodes and the base of the network which consists of two or more branches, and the network class as which 20 expresses the whole network, and 21 are the tree classes expressing the supply area of a power node. Thus, it becomes possible by building the model of a power-distribution-system network to the layered structure by the node class 17, the branch class 18, the graph class 19, the network class 20, and the tree class 21 for large-scale modeling to become easy and to

correspond also to specification modification flexibly.
[0038] Example 3., next the example 3 of this invention are explained about drawing. Drawing 4 is the conceptual diagram showing the class hierarchy of the distributing water pipe network by one example of invention according to claim 3. In drawing, the pipe class as a branch class as which 22 expresses a distributing water pipe, and 23 are the node classes expressing the branch point, and 24 is a water graph class used as the base of this distributing water pipe network. Thus, it becomes possible by building the model of a distributing water pipe network to the layered structure by the pipe class 22, the node class 23, and the water graph class 24 for large-scale modeling to become easy and to correspond also to specification modification flexibly.
[0039] Example 4., next the example 4 of this invention are explained about drawing. Drawing 5 is the conceptual diagram showing the class hierarchy of the communication network by one example of invention according to claim 4. In drawing, the line class as a branch class as which 25 expresses a communication link transmission line, and 26 are the node classes expressing a communication network node, and 27 is a communication link graph class used as the base of this communication network. Thus, it becomes possible by building the model of a distributing water pipe network to the layered structure by the line class 25, the node class 26, and the communication link graph class 27 for large-scale modeling to become easy and to correspond also to specification modification flexibly.
[0040] Example 5., next the example 5 of this invention are explained about drawing. Drawing 6 is the conceptual diagram showing the class hierarchy of the road network by one example of invention according to claim 5. In drawing, the load class as a branch class as which 28 expresses a road, and 29 are the intersection classes as a node class expressing a crossing, and 30 is a load graph class used as the base of this road network. Thus, it becomes possible by building the model of a road network to the layered structure by the load class 28, the intersection class 29, and the load graph class 30 for large-scale modeling to become easy and to correspond also to specification modification flexibly.
[0041] Example 6., next the example 6 of this invention are explained about drawing. Here, drawing 7 is a conceptual diagram for explaining the network rationalization approach by the examples 6-10 explained to this example 5 and the following. In drawing, 11 is the model of a genetic algorithm explained by drawing 1 , and 31 is a power-distribution-system network model as a model 12 for [at the time of setting a power-distribution-system network as the application target of the genetic algorithm] application. 32 is a distributing water pipe network model at the time of similarly setting a distributing water pipe network as an application target, and a communication link network model when 33 sets a communication network as an application target, and 34 are the road network models at the time of setting a road network as an application target. Moreover, 35 is the power-distribution-system load allocation-optimization section which optimizes the configuration of the power-distribution-system network by the power-distribution-system network model 31, and 36 is the power-distribution-system system-switching optimization section which optimizes a change-over of the network of the power-distribution-system network. 37 is the distributing water pipe network configuration optimization section which optimizes the configuration of the distributing water pipe network by the distributing water pipe network model 32, and the communication network configuration optimization section in which 38 optimizes the configuration of the communication network by the communication link network model 33, and 39 are the road network configuration optimization sections which optimize the configuration of the road network by the road network model 34.
[0042] As shown in drawing 7 , the model 11 of the genetic algorithm which is flexible beforehand is made. When the genetic algorithm is applied about candidates for application, such as a power-distribution-system network, The models 31-34 for [, such as the power-distribution-system network,] application are made independently [the model 11 of a genetic algorithm]. If these two models are combined like 11, 32, 11 and 33, or 11 and 34, the software for the optimization according to the object and purpose will complete them. [models 11 and 31,]
[0043] Drawing 8 is the conceptual diagram showing the interface between the model 11 of a genetic algorithm for explaining one example of invention according to claim 6, and the power-

distribution-system network model 31. In drawing, 40 is a abstract class showing a gene, it is a gene (Gene) class without an interface in itself, and 41 is a chromium (Chrom) class in which the class (for example, #1 - #n tree class 21) of the power-distribution-system network model 31 is mounted as a member. The gene class 40 does not have at all data about the power-distribution-system network which is a candidate for application with it, but 31 power-distribution-system network model#1 - #n tree class 21 are mounted as a member of the chromium class 41 so that it may mention later. It becomes possible to access to the power-distribution-system network model 31 which is a model for application in a heredity operator by this. Moreover, although the gene class 40 makes heredity operators, such as decussation, a member function, it defines as an empty function here and actual mounting is performed in the chromium class 41.
[0044] Next, the mounting approach of the genetic algorithm in this invention is explained according to the flow chart of drawing 9 . First, the prototype of the gene class 14 in the model 11 of a genetic algorithm is mounted at a step ST 1. Then, the model 12 for [, such as a power-distribution-system network,] application is created at a step ST 2, next in a step ST 3, the gene class 14 in consideration of the information is mounted, and processing is ended.
[0045] How to rationalize hereafter the configuration of the power-distribution-system network by the power-distribution-system load allocation rationalization section 35 shown in drawing 7 is explained. In addition, the case where each load node of a power-distribution-system network is assigned to a power node so that capacity of a power node may not be exceeded is explained here. The power-distribution-system load allocation rationalization section 35 defines the performance index F for optimization like the following (1) type.
[0046]
[Equation 1]

$$F=\sum_{i=1}^{Pmax} f\left(\sum_{j=1}^{\ell max} L_{ij}\ ,\ P_i\right) \quad \cdots\cdots \quad (1)$$

[0047] In addition, i, j and Pi in the above-mentioned (1) type, and Lij show the following, respectively.
i : number of a power node (1 <=i<=pmax)
j : the number of a load node (1 <=j<=lmax)
Pi Capacity Lij of the power node of the :number i: Capacity of the load node of the number j linked to the power node of a number i [0048] Moreover, the function f in the above-mentioned (1) type is given by the following (2) formulas.
[0049]
[Equation 2]

$$f\ (x,\ y) = \begin{cases} x\ ;\ x \leqq y \\ 0\ ;\ x > y \end{cases} \quad \cdots\cdots \quad (2)$$

[0050] Here, this performance index F shows the one where supply allowances are larger, or the desirable thing about each power node. By performing this [to the power node of a load node / rate] so that this performance index F may serve as max, the power-distribution-system load distribution rationalization section 35 optimizes the configuration of a power-distribution-system network.
[0051] Example 7., next the example 7 of this invention are explained. This example 7 is one example of invention indicated to claim 7, and the interface between the model 11 of a genetic algorithm and the power-distribution-system network model 31 is mounted as shown in drawing 8 like the case of an example 6.
[0052] How to rationalize hereafter system switching of the power-distribution-system network by the power-distribution-system system-switching rationalization section 36 shown in drawing 7 is explained. In addition, when a power node and a load node are given, the case where a network is switched so that the maximum capacity of the transmission line may serve as min is

explained here. The power-distribution-system system-switching rationalization section 36 defines the performance index F for optimization like the following (3) types.
[0053]
[Equation 3]
$$F = \max_{i} \{ CP_i \} \quad \cdots\cdots (3)$$

[0054] In addition, i and CPi in the above-mentioned (3) types The following are shown, respectively.
i : number of the transmission line
CPi : capacity of the transmission line of a number i [0055] By performing system switching of a power-distribution-system network so that this performance index F may serve as min, the power-distribution-system system-switching rationalization section 36 optimizes system switching of a power-distribution-system network.
[0056] Example 8., next the example 8 of this invention are explained about drawing. Drawing 10 is the conceptual diagram showing the interface between the models 11 of a genetic algorithm and the distributing water pipe network models 32 by one example of invention according to claim 8. In this case, the water graph class 24 of the distributing water pipe network model 32 is mounted in the chromium class 41 of the model 11 of a genetic algorithm as a member.
[0057] How to rationalize hereafter the configuration of the distributing water pipe network by the distributing water pipe network rationalization section 37 shown in drawing 7 is explained. In addition, when the supply part and consumption part of water are given, the case where a distributing water pipe is arranged so that the maximum capacity of a distributing water pipe may serve as min is explained here. The distributing water pipe network rationalization section 37 defines the performance index F for optimization like the following (4) types.
[0058]
[Equation 4]
$$F = \max_{i} \{ CW_i \} \quad \cdots\cdots (4)$$

[0059] In addition, i and CWi in the above-mentioned (4) types The following are shown, respectively.
i : number of a distributing water pipe
CWi : capacity of the distributing water pipe of a number i [0060] By arranging a distributing water pipe so that this performance index F may serve as min, the distributing water pipe network rationalization section 37 optimizes the configuration of a distributing water pipe network.
[0061] Example 9., next the example 9 of this invention are explained about drawing. Drawing 11 is the conceptual diagram showing the interface between the models 11 of a genetic algorithm and the communication link network models 33 by one example of invention according to claim 9. In this case, the communication link graph class 27 of the communication link network model 33 is mounted in the chromium class 41 of the model 11 of a genetic algorithm as a member.
[0062] How to rationalize hereafter the configuration of a communication network by the communication network rationalization section 38 shown in drawing 7 is explained. In addition, when the dispatch part and junction part of a signal are given, the case where a communication link transmission line is installed so that the maximum capacity of a communication link transmission line may serve as min is explained here. The communication network rationalization section 38 defines the performance index F for optimization like the following (5) types.
[0063]
[Equation 5]
$$F = \max_{i} \{ CC_i \} \quad \cdots\cdots (5)$$

[0064] In addition, i and CCi in the above-mentioned (5) types The following are shown, respectively.
i : number of a communication link transmission line

CCi : capacity of the communication link transmission line of a number i [0065] By setting up a communication link transmission line so that this performance index F may serve as min, the communication network rationalization section 38 optimizes the configuration of a communication network.
[0066] Example 10., next the example 10 of this invention are explained about drawing. Drawing 12 is the conceptual diagram showing the interface between the model 11 of a genetic algorithm by one example of invention according to claim 10, and the road network model 34. In this case, the load graph class 30 of the road network model 34 is mounted in the chromium class 41 of the model 11 of a genetic algorithm as a member.
[0067] How to rationalize hereafter the configuration of the road network by the road network rationalization section 39 shown in drawing 7 is explained. In addition, when the crossing of a road is given, the case where a road is arranged so that the maximum capacity of a road may serve as min is explained here. The road network rationalization section 39 defines the performance index F for optimization like the following (6) types.
[0068]
[Equation 6]

$$F = \max_{i} \{ CR_i \} \qquad \cdots\cdots (6)$$

[0069] In addition, i and CRi in the above-mentioned (6) types The following are shown, respectively.
i : number of a road
CRi : capacity of the road of a number i [0070] By arranging a road so that this performance index F may serve as min, the road network rationalization section 39 optimizes the configuration of a road network.
[0071] Example 11., next the example 11 of this invention are explained about drawing. Drawing 13 is the conceptual diagram showing the retrieval process of the radial network in one example of invention indicated to claim 11. In drawing, 42 is a node used as the criteria in a radial network, and 43 is a node which is in the equal distance from this node 42. First, one node of a radial network branch is taken up and let it be the node 42 used as criteria. Next, the distance from a node 42 used as these criteria considers the node which is not contained yet among the equal nodes 43 in a network. As shown in drawing 13 , supposing there are such three nodes 43, the case where one, two, and three nodes 43 are chosen at random from the three nodes 43 will be assumed. the node 43 chosen about each case since there were three kinds in the way of choosing which chooses one from three nodes 43 when the case where one node was chosen was taken up -- it adds to the radial network. The radial network concerned is searched by repeating such a process.
[0072] Moreover, drawing 14 is the conceptual diagram showing the generation method of the radial network in this example 11. In drawing, 44 is a source node and the node by which 45 adjoined this source node 44, and 46, 47 and 48 are the nodes which adjoined this node 45. In constituting a radial network from a source node 44, it adds the node 45 which adjoined the source node 44 first to a network. Next, since the node which adjoins this node 45 is three of nodes 46, 47, and 48, it chooses the number of arbitration, and the node of arbitration at random from these three nodes 46-48. For example, two, a node 46 and a node 47, are chosen and it is added to a network. A radial network is generated at random by adding a node one by one hereafter in the process same about the node which adjoins these nodes 46 and 47.
[0073]
[Effect of the Invention] As mentioned above, the gene template class which does not contain the data for application for the model of a genetic algorithm at all using an object oriented design according to invention according to claim 1, Since it constituted so that it might consider as the general-purpose model which has a gene class containing it and the model of the genetic algorithm might be combined with the model for application It becomes possible to apply a genetic algorithm general-purpose, without being dependent on the object which it is going to apply, and there is effectiveness which can also lessen the interface between the model of a

genetic algorithm and the model for application, and can generate software efficiently.
[0074] Moreover, since according to invention according to claim 2 it constituted so that a node class and the transmission line might be expressed for the power node and load node which are the component of a power-distribution-system network as a branch class, a network might be built to a bottom-up and a model might be made hierarchical, the flexible modeling of a power-distribution-system network becomes possible, and it can respond also to modification of a model flexibly, and is effective in still larger-scale modeling becoming easy.
[0075] Moreover, since according to invention according to claim 3 it constituted so that a branch class and a junction might be expressed for the distributing water pipe which is the component of a distributing water pipe network as a node class, a network might be built to a bottom-up and a model might be made hierarchical, the flexible modeling of a distributing water pipe network becomes possible, and it can respond also to modification of a model flexibly, and is effective in still larger-scale modeling becoming easy.
[0076] Moreover, since according to invention according to claim 4 it constituted so that a branch class and a communication network node might be expressed for the communication link transmission line which is the component of a communication network as a node class, a network might be built to a bottom-up and a model might be made hierarchical, the flexible modeling of a communication network becomes possible, and it can respond also to modification of a model flexibly, and is effective in still larger-scale modeling becoming easy.
[0077] Moreover, since according to invention according to claim 5 it constituted so that a branch class and a crossing might be expressed for the road which is the component of a road network as a node class, a network might be built to a bottom-up and a model might be made hierarchical, the flexible modeling of a road network becomes possible, and it can respond also to modification of a model flexibly, and is effective in still larger-scale modeling becoming easy.
[0078] Moreover, since according to invention according to claim 6 it constituted so that a performance index might be defined based on the delivery capacity of the power source of each power node, and the capacity of the load node connected to it, it might serve as max, and assignment to the power node of a load node might be performed, there is effectiveness which can optimize the configuration of the power-distribution-system network which mounted the genetic algorithm by the approach of invention indicated to claim 2.
[0079] Moreover, since according to invention according to claim 7 it constituted so that a performance index might be defined based on the capacity of each transmission line, it might serve as min, and system switching of a power-distribution-system network might be performed, there is effectiveness which can optimize system switching of the power-distribution-system network which applied the genetic algorithm by the approach of invention indicated to claim 2.
[0080] Moreover, since according to invention according to claim 8 it constituted so that a performance index might be defined based on the capacity of each distributing water pipe, it might serve as min, and a distributing water pipe might be arranged, there is effectiveness which can optimize the configuration of the distributing water pipe network which applied the genetic algorithm by the approach of invention indicated to claim 3.
[0081] Moreover, since according to invention according to claim 9 it constituted so that a performance index might be defined based on the capacity of each communication link transmission line, it might rub with min, and a communication link transmission line might be installed, there is effectiveness which can optimize the configuration of the communication network which applied the genetic algorithm by the approach of invention indicated to claim 4.
[0082] Moreover, since it constituted so that a performance index might be defined based on the capacity of each road, it might serve as min, and a road might be arranged when it could set to invention according to claim 10 and having been depended, there is effectiveness which can optimize the configuration of the road network which applied the genetic algorithm by the approach of invention indicated to claim 5.
[0083] Moreover, since according to invention according to claim 11 it constituted so that the node chosen from the node used as the criteria in the network constituted by the radial at random out of the node of the same distance might be added to the network, retrieval of a radial network is attained and there is effectiveness which can generate the initial solution in a genetic

algorithm efficiently.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the conceptual diagram showing the genetic algorithm mounting approach by the example 1 of this invention.
[Drawing 2] It is the conceptual diagram showing the class hierarchy of the genetic algorithm in the above-mentioned example.
[Drawing 3] It is the conceptual diagram showing the genetic algorithm mounting approach by the example 2 of this invention.
[Drawing 4] It is the conceptual diagram showing the genetic algorithm mounting approach by the example 3 of this invention.
[Drawing 5] It is the conceptual diagram showing the genetic algorithm mounting approach by the example 4 of this invention.
[Drawing 6] It is the conceptual diagram showing the genetic algorithm mounting approach by the example 5 of this invention.
[Drawing 7] It is a conceptual diagram for explaining the network optimization approach by the examples 6-10 of this invention.
[Drawing 8] It is the conceptual diagram showing the interface between the model of the genetic algorithm in the above-mentioned examples 6 and 7, and the model for application.
[Drawing 9] It is the flow chart which shows the application approach of the genetic algorithm in the above-mentioned examples 6-10.
[Drawing 10] It is the conceptual diagram showing the interface between the model of the genetic algorithm by the example 8 of this invention, and the model for application.
[Drawing 11] It is the conceptual diagram showing the interface between the model of the genetic algorithm by the example 9 of this invention, and the model for application.
[Drawing 12] It is the conceptual diagram showing the interface between the model of the genetic algorithm by the example 10 of this invention, and the model for application.
[Drawing 13] It is the conceptual diagram showing the search method of the radial network in the example 11 of this invention.
[Drawing 14] It is the conceptual diagram showing the configuration approach of the radial network in the above-mentioned example.
[Drawing 15] It is the conceptual diagram showing the framework of the conventional genetic algorithm.
[Drawing 16] It is the explanatory view showing an example of the conventional power-distribution-system network.
[Description of Notations]
11 Model of Genetic Algorithm
12 Model for Application
13 Gene Template Class
14 Gene Class
17 Node Class
18 Branch Class
22 Branch Class (Pipe Class)

23 Node Class
25 Branch Class (Line Class)
26 Node Class
28 Branch Class (Load Class)
29 Node Class (Intersection Class)
31 Power-Distribution-System Network Model
32 Distributing Water Pipe Network Model
33 Communication Link Network Model
34 Road Network Model
42, 43, 45-48 Node
44 Source Node

[Translation done.]

CORRECTION OR AMENDMENT

[Kind of official gazette] Printing of amendment by the convention of 2 of Article 17 of Patent Law
[Section partition] The 3rd partition of the 6th section
[Publication date] February 9, Heisei 13 (2001. 2.9)

[Publication No.] JP,7-44519,A
[Date of Publication] February 14, Heisei 7 (1995. 2.14)
[Annual volume number] Open patent official report 7-446
[Application number] Japanese Patent Application No. 5-192564
[The 7th edition of International Patent Classification]

G06F 15/18 550
// G06F 9/44 550

[FI]

G06F 15/18 550 C
9/44 550 R

[Procedure revision]
[Filing Date] February 14, Heisei 12 (2000. 2.14)
[Procedure amendment 1]
[Document to be Amended] Specification
[Item(s) to be Amended] Whole sentence
[Method of Amendment] Modification
[Proposed Amendment]
[Document Name] Specification
[Title of the Invention] The genetic algorithm mounting approach and the network optimization approach using it
[Claim(s)]
[Claim 1] The genetic algorithm mounting approach which adopts an object oriented design, considers as the hierarchical model which has the gene class which are the gene template class which does not contain at all the data of said object which is going to apply the model of said genetic algorithm, and a subclass containing the data of said object which it is going to apply in the genetic algorithm mounting approach of mounting the genetic algorithm which is the approach of optimizing an object, and is characterized by to combine with the model of said object which is going to apply the genetic algorithm concerned.
[Claim 2] The genetic algorithm mounting approach according to claim 1 which sets a power-distribution-system network as said target which it is going to apply, expresses a node class and the transmission line between each node for the power node and load node which are the component of said power-distribution-system network as a branch class, builds a network to a bottom-up, and is characterized by modeling said power-distribution-system network

hierarchical.

[Claim 3] The genetic algorithm mounting approach according to claim 1 which sets a distributing water pipe network as said target which it is going to apply, expresses a branch class and a junction for the distributing water pipe which is the component of said distributing water pipe network as a node class, builds a network to a bottom-up, and is characterized by modeling said distributing water pipe network hierarchical.

[Claim 4] The genetic algorithm mounting approach according to claim 1 which sets a communication network as said target which it is going to apply, expresses a branch class and a communication network node for the communication link transmission line which is the component of said communication network as a node class, builds a network to a bottom-up, and is characterized by modeling said communication network hierarchical.

[Claim 5] The genetic algorithm mounting approach according to claim 1 which sets a road network as said target which it is going to apply, expresses a branch class and a crossing for the road which is the component of said road network as a node class, builds a network to a bottom-up, and is characterized by modeling said road network hierarchical.

[Claim 6] The network optimization approach characterized by performing this [to said power node of said load node / rate] so that the performance index defined based on the delivery capacity of the power source of each power node of said power-distribution-system network model and the capacity of the load node connected to it in the network optimization approach which optimizes the configuration of the power-distribution-system network which mounted the genetic algorithm using the approach of invention indicated to claim 2 may be made into max.

[Claim 7] The network optimization approach characterized by performing system switching of said power-distribution-system network so that the performance index defined based on the capacity of each transmission line of said power-distribution-system network model may be made into min in the network optimization approach which optimizes system switching of the power-distribution-system network which mounted the genetic algorithm using the approach of invention indicated to claim 2.

[Claim 8] The network optimization approach characterized by arranging said distributing water pipe so that the performance index defined based on the capacity of each distributing water pipe of said distributing water pipe network model may be made into min in the network optimization approach which optimizes the configuration of the distributing water pipe network which mounted the genetic algorithm using the approach of invention indicated to claim 3.

[Claim 9] The network optimization approach characterized by installing said communication link transmission line so that the performance index defined based on the capacity of each communication link transmission line of said communication link network model may be made into min in the network optimization approach which optimizes the configuration of the communication network which mounted the genetic algorithm using the approach of invention indicated to claim 4.

[Claim 10] The network optimization approach characterized by arranging said road so that the performance index defined based on the capacity of each road of said road network model may be made into min in the network optimization approach which optimizes the configuration of the road network which mounted the genetic algorithm using the approach of invention indicated to claim 5.

[Claim 11] The genetic algorithm mounting approach characterized by searching the network of the radial concerned by adding the node which the distance from a node used as the criteria in the network of said radial chose from the inside of an equal node in the genetic algorithm mounting approach which searches the network constituted by the radial and applies a genetic algorithm to the network of said radial.

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the network optimization approach using the genetic algorithm mounting approach and its genetic algorithm mounting approach for applying the genetic algorithm which is the approach of optimizing the object of arbitration to that object.

[0002]

[Description of the Prior Art] Drawing 15 is the conceptual diagram showing the genetic algorithm which is the approach of optimizing the object of arbitration shown in "the present condition and the technical problem" (Shigenobu Kobayashi Society of Instrument and Control Engineers society magazine "measurement and control" of volume [32nd] 1 No. 2-9th page 1993 January) of a genetic algorithm. In drawing, 1 is the process of initialization by a certain generation's gene cluster, and 2 is the process of the duplicate which reproduces a gene and forms a next-generation gene cluster. 3 is the process of the decussation which makes a gene a group and replaces the part, and 4 is the process of mutation in which it is exchanged in a part of gene.

[0003] Next, actuation is explained. First, optimization of the object by such genetic algorithm is explained. In a genetic algorithm, the candidate for application which it is going to optimize is expressed by a character string etc., and it considers that it is a gene, and rationalizes about two or more genes. The general procedure of this genetic algorithm consists of the process 1 of initialization shown in drawing 15, the process 2 of a duplicate, a process 3 of decussation, and a process 4 of mutation. Namely, what expressed a certain generation's initialized gene cluster typically shows a gene by 1 of drawing 15, and, as for the circle in drawing, the pattern in a circle expresses the phenotype of each gene, respectively. Next, a gene is reproduced in process of [2] a duplicate, and a next-generation gene is formed. It is made for more high things of evaluation to remain on the occasion of the duplicate of this gene. Next, the crossover of a gene is performed in the process 3 of decussation. The retrieval range of a solution is expanded rather than an initial population by the crossover of this gene making a gene a group at random, and exchanging some each other and carrying out like this. Next, the mutation of a gene is generated in process of [4] mutation. This mutation makes it generate by exchanging one character of a gene by a certain low probability, and makes escape from a local solution easy by this. The high gene of evaluation is obtained by repeating such initialization, a duplicate, decussation, and the cycle by each process of mutation.

[0004] Moreover, drawing 16 is the explanatory view showing the model of the conventional power-distribution-system network shown in "the power-distribution-system facility extension plan under which the time of accident was taken into consideration" (binary name outside Hirokazu Nara -115 Institute of Electrical Engineers of Japan study group data power technical study group PE-91 1991 October). In the model of this power-distribution-system network, a substation, a transformer, and a load are expressed as a node and a feeder, the transmission line, etc. between each node are expressed as a branch, respectively. In drawing, for 5, as for a transformer node and 7, a source node and 6 are [a substation node and 8] load nodes, 9 is an establishment feeder and 10 is an established feeder.

[0005] In addition, it was required to build software according to the object applied, when it mounts a genetic algorithm in the network set as the object of such application, and when mounting of said duplicate, decussation, and the heredity operator of mutation was changed, software was remade from the beginning. Moreover, when building the model for [of a genetic algorithm] application, and the model became large-scale, it was hard coming to grasp the configuration as a whole, and was a thing accompanied by difficulty in construction of a large-scale model.

[0006]

[Problem(s) to be Solved by the Invention] Since the conventional genetic algorithm was constituted as mentioned above, it was lacking in versatility, and since flexibility was lacked in the target modeling or the correspondence to model modification in case it is applied to the target network, the creation effectiveness of software was low, and there were troubles, such as following difficulty also on network optimization.

[0007] It was made in order that this invention might cancel the above troubles, and invention according to claim 1 enables construction of the model of the general-purpose high genetic algorithm of reusability, and aims at acquiring the genetic algorithm mounting approach that the increase in efficiency of software creation can be calculated.

[0008] Moreover, invention according to claim 2 to 5 aims at acquiring the genetic algorithm mounting approach which can respond also to modification of a model flexibly while the flexible

modeling of the network which is a candidate for application becomes possible.
[0009] Moreover, invention according to claim 6 to 10 aims at acquiring the network optimization approach which can optimize a network easily.
[0010] Moreover, invention according to claim 11 aims at acquiring the genetic algorithm mounting approach in which the increase in efficiency of generation of the initial solution in a genetic algorithm is possible.
[0011]
[Means for Solving the Problem] The genetic algorithm mounting approach concerning invention according to claim 1 combines it with the model for application by adopting an object oriented design as a layered structure which has the gene template class which does not contain the data for application for the model of a genetic algorithm at all, and a gene class containing it.
[0012] Moreover, the genetic algorithm mounting approach concerning invention according to claim 2 expresses the power node of the power-distribution-system network for application, a load node, and the transmission line as a node class or a branch class, and a power-distribution-system network is built to a bottom-up, and it models it hierarchical.
[0013] Moreover, the genetic algorithm mounting approach concerning invention according to claim 3 expresses the distributing water pipe of the distributing water pipe network for application, and a junction as a branch class or a node class, and a distributing water pipe network is built to a bottom-up, and it models it hierarchical.
[0014] Moreover, the genetic algorithm mounting approach concerning invention according to claim 4 expresses the communication link transmission line of the communication network for application, and a communication network node as a branch class or a node class, and a communication network is built to a bottom-up and it models it hierarchical.
[0015] Moreover, the genetic algorithm mounting approach concerning invention according to claim 5 expresses the road of the road network for application, and a crossing as a branch class or a node class, and a road network is built to a bottom-up and it models it hierarchical.
[0016] Moreover, the network optimization approach concerning invention according to claim 6 defines a performance index based on the capacity of the load node connected to the current supply capacity of each of that power node, and it about the power-distribution-system network which mounted the genetic algorithm by the approach according to claim 2, and it performs this [to the power node of a load node / rate] so that it may serve as max.
[0017] Moreover, the network optimization approach concerning invention according to claim 7 defines a performance index based on the capacity of each of that transmission line about the power-distribution-system network which mounted the genetic algorithm by the approach according to claim 2, and it performs system switching of a power-distribution-system network so that it may serve as min.
[0018] Moreover, the network optimization approach concerning invention according to claim 8 defines a performance index based on the capacity of each of that distributing water pipe about the distributing water pipe network which mounted the genetic algorithm by the approach according to claim 3, and it arranges a distributing water pipe so that it may serve as min.
[0019] Moreover, the network optimization approach concerning invention according to claim 9 defines a performance index based on the capacity of each of that communication link transmission line about the communication network which mounted the genetic algorithm by the approach according to claim 4, and it installs a communication link transmission line so that it may serve as min.
[0020] Moreover, the network optimization approach concerning invention according to claim 10 defines a performance index based on the capacity of each of that road about the road network which mounted the genetic algorithm by the approach according to claim 5, and it arranges a road so that it may serve as min.
[0021] Moreover, the distance from a node used as the criteria in the network constituted by the radial chooses a node at random out of an equal node, and the genetic algorithm mounting approach concerning invention according to claim 11 searches the radial network concerned by adding it to the network.
[0022]

[Function] By adopting an object oriented design and mounting the model of a genetic algorithm, the genetic algorithm mounting approach in invention according to claim 1 is made into the high genetic algorithm of versatility independent of the object which it is going to apply using the gene template class which does not contain the data for application at all, and the gene class containing it, and makes generation of software efficient.
[0023] Moreover, by expressing a node class and the transmission line for the power node and load node which are a component as a branch class, a power-distribution-system network is built to a bottom-up, and the genetic algorithm mounting approach in invention according to claim 2 models it hierarchical.
[0024] Moreover, by expressing a branch class and a junction for the distributing water pipe which is a component as a node class, a distributing water pipe network is built to a bottom-up, and the genetic algorithm application approach in invention according to claim 3 models it hierarchical.
[0025] Moreover, by expressing a branch class and a communication network node for the communication link transmission line which is a component as a node class, a communication network is built to a bottom-up and the genetic algorithm application approach in invention according to claim 4 models it hierarchical.
[0026] Moreover, by expressing a branch class and a crossing for the road which is a component as a node class, a road network is built to a bottom-up and the genetic algorithm application approach in invention according to claim 5 models it hierarchical.
[0027] Moreover, the network optimization approach in invention according to claim 6 optimizes the configuration of the power-distribution-system network which mounted the genetic algorithm using the approach of invention indicated to claim 2 by performing this [to the power node of a load node / rate] so that the performance index defined based on the delivery capacity of the power source of each power node and the capacity of the load node connected to it may serve as max.
[0028] Moreover, the network optimization approach in invention according to claim 7 optimizes system switching of the power-distribution-system network which applied the genetic algorithm by the approach of invention indicated to claim 2 by performing system switching of a power-distribution-system network so that the performance index defined based on the capacity of each transmission line may serve as min.
[0029] Moreover, the network optimization approach in invention according to claim 8 optimizes the configuration of the distributing water pipe network which applied the genetic algorithm by the approach of invention indicated to claim 3 by arranging a distributing water pipe so that the performance index defined based on the capacity of each distributing water pipe may serve as min.
[0030] Moreover, the network optimization approach in invention according to claim 9 optimizes the configuration of the communication network which applied the genetic algorithm by the approach of invention indicated to claim 4 by installing a communication link transmission line so that the performance index defined based on the capacity of each communication link transmission line may serve as min.
[0031] Moreover, the network optimization approach in invention according to claim 10 optimizes the configuration of the road network which applied the genetic algorithm by the approach of invention indicated to claim 5 by arranging a road so that the performance index defined based on the capacity of each road may serve as min.
[0032] Moreover, the genetic algorithm mounting approach in invention according to claim 11 generates the initial solution in a genetic algorithm efficiently by adding the node which the distance from a node used as the criteria in the network constituted by the radial chose at random out of the equal node to the network, and searching the radial network concerned.
[0033]
[Example] Example 1
Hereafter, the example 1 of this invention is explained about drawing. Drawing 1 is the conceptual diagram showing the genetic algorithm mounting approach by one example of invention according to claim 1. In drawing, 11 is the model of a genetic algorithm and 12 is a

model for application with which this genetic algorithm is applied. In addition, a thing required as data for application is only the genotype of a gene in the model 11 of this genetic algorithm, and a thing required of the model 12 for application is only the phenotype of a gene. Therefore, it dissociates as an interface between the model 11 of a genetic algorithm, and the model 12 for application, and they are built.

[0034] Moreover, drawing 2 is the conceptual diagram showing the class hierarchy of a genetic algorithm. In drawing, 13 is a gene template class in the least significant of the genetic algorithm concerned, and 14 is a gene class as a subclass which inherited this gene template class 13. It is the population class which 15 has in the high order of this gene class 14, and has the gene class 14 in a member, and 16 is an application class which is in the high order of this population class 15, and has the population class 15 in a member.

[0035] Next, actuation is explained. In addition, the information for application is not included in the gene template class 13 at all, and a heredity operator is not mounted only by declaration, either. As for the gene class 14, a heredity operator is also mounted here including the information for application. Therefore, if it sees from the class of the hierarchy above the gene class 14, member functions, such as a member and a heredity operator, will not be influenced of the data for application. For example, if the member function which shows the ″duplicate″ which is one of the heredity operators is set to ″reproduce″, ″reproduce″ will be an empty function in the gene template class 13, and actual contents will be described by the gene class 14. In the class above the gene class 14, if the function which shows a ″duplicate″ is described to be ″reproduce″, it does not need to be concerned with the candidate for application and it is not necessary to change the model 11 of a genetic algorithm.

[0036] Thus, let the interfaces for application be fewer things by the genetic algorithm mounting approach by this example 1 by using the gene class 14 as abstract data type, and mounting the heredity operator who doubled with the information for application, or it by that subclass.

[0037] Example 2

Next, the example 2 of this invention is explained about drawing. Drawing 3 is the conceptual diagram showing the class hierarchy of the power-distribution-system network by one example of invention according to claim 2. In drawing, 17 is a node class expressing a power node and a load node, and 18 is a branch class expressing branches, such as the transmission line which connects between nodes. 19 is a graph class used as two or more nodes and the base of the network which consists of two or more branches, and the network class as which 20 expresses the whole network, and 21 are the tree classes expressing the supply area of a power node. Thus, it becomes possible by building the model of a power-distribution-system network to the layered structure by the node class 17, the branch class 18, the graph class 19, the network class 20, and the tree class 21 for large-scale modeling to become easy and to correspond also to specification modification flexibly.

[0038] Example 3

Next, the example 3 of this invention is explained about drawing. Drawing 4 is the conceptual diagram showing the class hierarchy of the distributing water pipe network by one example of invention according to claim 3. In drawing, the pipe class as a branch class as which 22 expresses a distributing water pipe, and 23 are the node classes expressing the branch point, and 24 is a water graph class used as the base of this distributing water pipe network. Thus, it becomes possible by building the model of a distributing water pipe network to the layered structure by the pipe class 22, the node class 23, and the water graph class 24 for large-scale modeling to become easy and to correspond also to specification modification flexibly.

[0039] Example 4

Next, the example 4 of this invention is explained about drawing. Drawing 5 is the conceptual diagram showing the class hierarchy of the communication network by one example of invention according to claim 4. In drawing, the line class as a branch class as which 25 expresses a communication link transmission line, and 26 are the node classes expressing a communication network node, and 27 is a communication link graph class used as the base of this communication network. Thus, it becomes possible by building the model of a communication network to the layered structure by the line class 25, the node class 26, and the communication

link graph class 27 for large-scale modeling to become easy and to correspond also to specification modification flexibly.

[0040] Example 5

Next, the example 5 of this invention is explained about drawing. Drawing 6 is the conceptual diagram showing the class hierarchy of the road network by one example of invention according to claim 5. In drawing, the load class as a branch class as which 28 expresses a road, and 29 are the intersection classes as a node class expressing a crossing, and 30 is a load graph class used as the base of this road network. Thus, it becomes possible by building the model of a road network to the layered structure by the load class 28, the intersection class 29, and the load graph class 30 for large-scale modeling to become easy and to correspond also to specification modification flexibly.

[0041] Example 6

Next, the example 6 of this invention is explained about drawing. Here, drawing 7 is a conceptual diagram for explaining the network rationalization approach by the examples 6-10 explained to this example 5 and the following. In drawing, 11 is the model of a genetic algorithm explained by drawing 1, and 31 is a power-distribution-system network model as a model 12 for [at the time of setting a power-distribution-system network as the application target of the genetic algorithm] application. 32 is a distributing water pipe network model at the time of similarly setting a distributing water pipe network as an application target, and a communication link network model when 33 sets a communication network as an application target, and 34 are the road network models at the time of setting a road network as an application target. Moreover, 35 is the power-distribution-system load allocation-optimization section which optimizes the configuration of the power-distribution-system network by the power-distribution-system network model 31, and 36 is the power-distribution-system system-switching optimization section which optimizes a change-over of the network of the power-distribution-system network. 37 is the distributing water pipe network configuration optimization section which optimizes the configuration of the distributing water pipe network by the distributing water pipe network model 32, and the communication network configuration optimization section in which 38 optimizes the configuration of the communication network by the communication link network model 33, and 39 are the road network configuration optimization sections which optimize the configuration of the road network by the road network model 34.

[0042] The model 11 of the genetic algorithm which is flexible beforehand as shown in drawing 7 If the models 31-34 for [, such as the power-distribution-system network,] application are made independently [the model 11 of a genetic algorithm] and these two models are combined like 11, 32, 11 and 33, or 11 and 34 when making and applying the genetic algorithm about candidates for application, such as a power-distribution-system network, the software for the optimization according to the object and purpose will be completed. [models 11 and 31,]

[0043] Drawing 8 is the conceptual diagram showing the interface between the model 11 of a genetic algorithm for explaining one example of invention according to claim 6, and the power-distribution-system network model 31. In drawing, 40 is a abstract class showing a gene, it is a gene (Gene) class without an interface in itself, and 41 is a chromium (Chrom) class in which the class (for example, #1 - #n tree class 21) of the power-distribution-system network model 31 is mounted as a member. The gene class 40 does not have at all data about the power-distribution-system network which is a candidate for application with it, but 31 power-distribution-system network model#1 - #n tree class 21 are mounted as a member of the chromium class 41 so that it may mention later. It becomes possible to access to the power-distribution-system network model 31 which is a model for application in a heredity operator by this. Moreover, although the gene class 40 makes heredity operators, such as decussation, a member function, it defines as an empty function here and actual mounting is performed in the chromium class 41.

[0044] Next, the mounting approach of the genetic algorithm in this invention is explained according to the flow chart of drawing 9. First, the prototype of the gene class 14 in the model 11 of a genetic algorithm is mounted at a step ST 1. Then, the model 12 for [, such as a power-distribution-system network,] application is created at a step ST 2, next in a step ST 3, the

gene class 14 in consideration of the information is mounted, and processing is ended.
[0045] How to rationalize hereafter the configuration of the power-distribution-system network by the power-distribution-system load allocation-optimization section 35 shown in drawing 7 is explained. In addition, the case where each load node of a power-distribution-system network is assigned to a power node so that capacity of a power node may not be exceeded is explained here. The power-distribution-system load allocation-optimization section 35 defines the performance index F for optimization like the following (1) type.
[0046]
[Equation 1]

$$F=\sum_{i=1}^{Pmax} f\left(\sum_{j=1}^{\ell max} L_{ij}\ ,\ P_i\right) \quad \cdots\cdots (1)$$

[0047] In addition, i, j, Pi, and Lij in the above-mentioned (1) type show the following, respectively.
i : number of a power node (1 <=i<=pmax)
j : the number of a load node (1 <=j<=lmax)
Pi : capacity of the power node of a number i
Lij: Capacity of the load node of the number j linked to the power node of a number i
[0048] Moreover, the function f in the above-mentioned (1) type is given by the following (2) formulas.
[0049]
[Equation 2]

$$f(x,\ y)=\begin{cases} x\ ;\ x \leqq y \\ 0\ ;\ x > y \end{cases} \quad \cdots\cdots (2)$$

[0050] Here, it is shown that this performance index F has the desirable one where supply allowances are larger about each power node. By performing this [to the power node of a load node / rate] so that this performance index F may serve as max, the power-distribution-system load distribution optimization section 35 optimizes the configuration of a power-distribution-system network.
[0051] Example 7
Next, the example 7 of this invention is explained. This example 7 is one example of invention indicated to claim 7, and the interface between the model 11 of a genetic algorithm and the power-distribution-system network model 31 is mounted as shown in drawing 8 like the case of an example 6.
[0052] How to rationalize hereafter system switching of the power-distribution-system network by the power-distribution-system system-switching optimization section 36 shown in drawing 7 is explained. In addition, when a power node and a load node are given, the case where a network is switched so that the maximum capacity of the transmission line may serve as min is explained here. The power-distribution-system system-switching optimization section 36 defines the performance index F for optimization like the following (3) types.
[0053]
[Equation 3]

$$F=\max_{i}\{\ CP_i\ \} \quad \cdots\cdots (3)$$

[0054] In addition, i and CPi in the above-mentioned (3) types The following are shown, respectively.
i : number of the transmission line
CPi : capacity of the transmission line of a number i
[0055] By performing system switching of a power-distribution-system network so that this performance index F may serve as min, the power-distribution-system system-switching optimization section 36 optimizes system switching of a power-distribution-system network.
[0056] Example 8
Next, the example 8 of this invention is explained about drawing. Drawing 10 is the conceptual diagram showing the interface between the models 11 of a genetic algorithm and the distributing water pipe network models 32 by one example of invention according to claim 8. In this case, the water graph class 24 of the distributing water pipe network model 32 is mounted in the chromium class 41 of the model 11 of a genetic algorithm as a member.
[0057] How to rationalize hereafter the configuration of the distributing water pipe network by the distributing water pipe network configuration optimization section 37 shown in drawing 7 is explained. In addition, when the supply part and consumption part of water are given, the case where a distributing water pipe is arranged so that the maximum capacity of a distributing water pipe may serve as min is explained here. The distributing water pipe network configuration optimization section 37 defines the performance index F for optimization like the following (4) types.
[0058]
[Equation 4]

$$F = \max_{i} \{ CW_i \} \quad \cdots\cdots \quad (4)$$

[0059] In addition, i and CWi in the above-mentioned (4) types The following are shown, respectively.
i : number of a distributing water pipe
CWi : capacity of the distributing water pipe of a number i
[0060] By arranging a distributing water pipe so that this performance index F may serve as min, the distributing water pipe network configuration optimization section 37 optimizes the configuration of a distributing water pipe network.
[0061] Example 9
Next, the example 9 of this invention is explained about drawing. Drawing 11 is the conceptual diagram showing the interface between the models 11 of a genetic algorithm and the communication link network models 33 by one example of invention according to claim 9. In this case, the communication link graph class 27 of the communication link network model 33 is mounted in the chromium class 41 of the model 11 of a genetic algorithm as a member.
[0062] How to rationalize hereafter the configuration of a communication network by the communication network configuration optimization section 38 shown in drawing 7 is explained. In addition, when the dispatch part and junction part of a signal are given, the case where a communication link transmission line is installed so that the maximum capacity of a communication link transmission line may serve as min is explained here. The communication network configuration optimization section 38 defines the performance index F for optimization like the following (5) types.
[0063]
[Equation 5]

$$F = \max_{i} \{ CC_i \} \quad \cdots\cdots \quad (5)$$

[0064] In addition, i and CCi in the above-mentioned (5) types The following are shown, respectively.

i : number of a communication link transmission line

CCi : capacity of the communication link transmission line of a number i

[0065] By setting up a communication link transmission line so that this performance index F may serve as min, the communication network configuration optimization section 38 optimizes the configuration of a communication network.

[0066] Example 10

Next, the example 10 of this invention is explained about drawing. Drawing 12 is the conceptual diagram showing the interface between the model 11 of a genetic algorithm by one example of invention according to claim 10, and the road network model 34. In this case, the load graph class 30 of the road network model 34 is mounted in the chromium class 41 of the model 11 of a genetic algorithm as a member.

[0067] How to rationalize hereafter the configuration of the road network by the road network configuration optimization section 39 shown in drawing 7 is explained. In addition, when the crossing of a road is given, the case where a road is arranged so that the maximum capacity of a road may serve as min is explained here. The road network configuration optimization section 39 defines the performance index F for optimization like the following (6) types.

[0068]

[Equation 6]

$$F = \max_{i} \{ CR_i \} \quad \cdots\cdots \quad (6)$$

[0069] In addition, i and CRi in the above-mentioned (6) types The following are shown, respectively.

i : number of a road

CRi : capacity of the road of a number i

[0070] By arranging a road so that this performance index F may serve as min, the road network configuration optimization section 39 optimizes the configuration of a road network.

[0071] Example 11

Next, the example 11 of this invention is explained about drawing. Drawing 13 is the conceptual diagram showing the retrieval process of the radial network in one example of invention indicated to claim 11. In drawing, 42 is a node used as the criteria in a radial network, and 43 is a node which is in the equal distance from this node 42. First, one node of a radial network branch is taken up and let it be the node 42 used as criteria. Next, the distance from a node 42 used as these criteria considers the node which is not contained yet among the equal nodes 43 in a network. As shown in drawing 13, supposing there are such three nodes 43, the case where one, two, and three nodes 43 are chosen at random from the three nodes 43 will be assumed. Since there are three kinds in the way of choosing which chooses one from three nodes 43 when the case where one node is chosen is taken up, the selected node 43 is added to the radial network about each case. The radial network concerned is searched by repeating such a process.

[0072] Moreover, drawing 14 is the conceptual diagram showing the generation method of the radial network in this example 11. In drawing, 44 is a source node and the node by which 45 adjoined this source node 44, and 46, 47 and 48 are the nodes which adjoined this node 45. In constituting a radial network from a source node 44, it adds the node 45 which adjoined the source node 44 first to a network. Next, since the node which adjoins this node 45 is three of nodes 46, 47, and 48, it chooses the number of arbitration, and the node of arbitration at random from these three nodes 46-48. For example, two, a node 46 and a node 47, are chosen and it is added to a network. A radial network is generated at random by adding a node one by one hereafter in the process same about the node which adjoins these nodes 46 and 47.

[0073]

[Effect of the Invention] As mentioned above, the gene template class which does not contain the data for application for the model of a genetic algorithm at all using an object oriented design according to invention according to claim 1, Since it constituted so that it might consider as the general-purpose model which has a gene class containing it and the model of the genetic

algorithm might be combined with the model for application, it can become possible to apply a genetic algorithm general-purpose, without being dependent on the object which it is going to apply, the interface between the model of a genetic algorithm and the model for application can also be lessened, and there is effectiveness which can generate software efficiently.
[0074] Moreover, since according to invention according to claim 2 it constituted so that a node class and the transmission line might be expressed for the power node and load node which are the component of a power-distribution-system network as a branch class, a network might be built to a bottom-up and a model might be made hierarchical, the flexible modeling of a power-distribution-system network becomes possible, and it can respond also to modification of a model flexibly, and is effective in still larger-scale modeling becoming easy.
[0075] Moreover, since according to invention according to claim 3 it constituted so that a branch class and a junction might be expressed for the distributing water pipe which is the component of a distributing water pipe network as a node class, a network might be built to a bottom-up and a model might be made hierarchical, the flexible modeling of a distributing water pipe network becomes possible, and it can respond also to modification of a model flexibly, and is effective in still larger-scale modeling becoming easy.
[0076] Moreover, since according to invention according to claim 4 it constituted so that a branch class and a communication network node might be expressed for the communication link transmission line which is the component of a communication network as a node class, a network might be built to a bottom-up and a model might be made hierarchical, the flexible modeling of a communication network becomes possible, and it can respond also to modification of a model flexibly, and is effective in still larger-scale modeling becoming easy.
[0077] Moreover, since according to invention according to claim 5 it constituted so that a branch class and a crossing might be expressed for the road which is the component of a road network as a node class, a network might be built to a bottom-up and a model might be made hierarchical, the flexible modeling of a road network becomes possible, and it can respond also to modification of a model flexibly, and is effective in still larger-scale modeling becoming easy.
[0078] Moreover, since according to invention according to claim 6 it constituted so that a performance index might be defined based on the delivery capacity of the power source of each power node, and the capacity of the load node connected to it, it might serve as max, and assignment to the power node of a load node might be performed, there is effectiveness which can optimize the configuration of the power-distribution-system network which mounted the genetic algorithm by the approach of invention indicated to claim 2.
[0079] Moreover, since according to invention according to claim 7 it constituted so that a performance index might be defined based on the capacity of each transmission line, it might serve as min, and system switching of a power-distribution-system network might be performed, there is effectiveness which can optimize system switching of the power-distribution-system network which applied the genetic algorithm by the approach of invention indicated to claim 2.
[0080] Moreover, since according to invention according to claim 8 it constituted so that a performance index might be defined based on the capacity of each distributing water pipe, it might serve as min, and a distributing water pipe might be arranged, there is effectiveness which can optimize the configuration of the distributing water pipe network which applied the genetic algorithm by the approach of invention indicated to claim 3.
[0081] Moreover, since according to invention according to claim 9 it constituted so that a performance index might be defined based on the capacity of each communication link transmission line, it might serve as min, and a communication link transmission line might be installed, there is effectiveness which can optimize the configuration of the communication network which applied the genetic algorithm by the approach of invention indicated to claim 4.
[0082] Moreover, since according to invention according to claim 10 it constituted so that a performance index might be defined based on the capacity of each road, it might serve as min, and a road might be arranged, there is effectiveness which can optimize the configuration of the road network which applied the genetic algorithm by the approach of invention indicated to claim 5.
[0083] Moreover, since according to invention according to claim 11 it constituted so that the

node chosen from the node used as the criteria in the network constituted by the radial at random out of the node of the same distance might be added to the network, retrieval of a radial network is attained and there is effectiveness which can generate the initial solution in a genetic algorithm efficiently.

[Brief Description of the Drawings]

[Drawing 1] It is the conceptual diagram showing the genetic algorithm mounting approach by the example 1 of this invention.

[Drawing 2] It is the conceptual diagram showing the class hierarchy of the genetic algorithm in the above-mentioned example.

[Drawing 3] It is the conceptual diagram showing the genetic algorithm mounting approach by the example 2 of this invention.

[Drawing 4] It is the conceptual diagram showing the genetic algorithm mounting approach by the example 3 of this invention.

[Drawing 5] It is the conceptual diagram showing the genetic algorithm mounting approach by the example 4 of this invention.

[Drawing 6] It is the conceptual diagram showing the genetic algorithm mounting approach by the example 5 of this invention.

[Drawing 7] It is a conceptual diagram for explaining the network optimization approach by the examples 6-10 of this invention.

[Drawing 8] It is the conceptual diagram showing the interface between the model of the genetic algorithm in the above-mentioned examples 6 and 7, and the model for application.

[Drawing 9] It is the flow chart which shows the application approach of the genetic algorithm in the above-mentioned examples 6-10.

[Drawing 10] It is the conceptual diagram showing the interface between the model of the genetic algorithm by the example 8 of this invention, and the model for application.

[Drawing 11] It is the conceptual diagram showing the interface between the model of the genetic algorithm by the example 9 of this invention, and the model for application.

[Drawing 12] It is the conceptual diagram showing the interface between the model of the genetic algorithm by the example 10 of this invention, and the model for application.

[Drawing 13] It is the conceptual diagram showing the search method of the radial network in the example 11 of this invention.

[Drawing 14] It is the conceptual diagram showing the configuration approach of the radial network in the above-mentioned example.

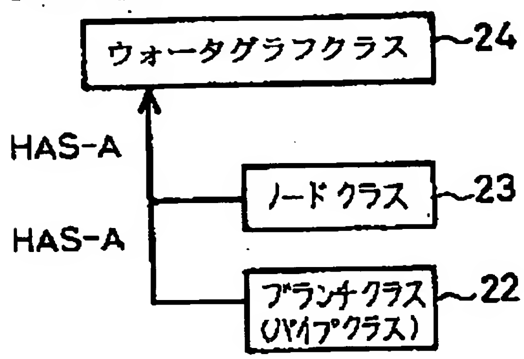
[Drawing 15] It is the conceptual diagram showing the framework of the conventional genetic algorithm.

[Drawing 16] It is the explanatory view showing an example of the conventional power-distribution-system network.

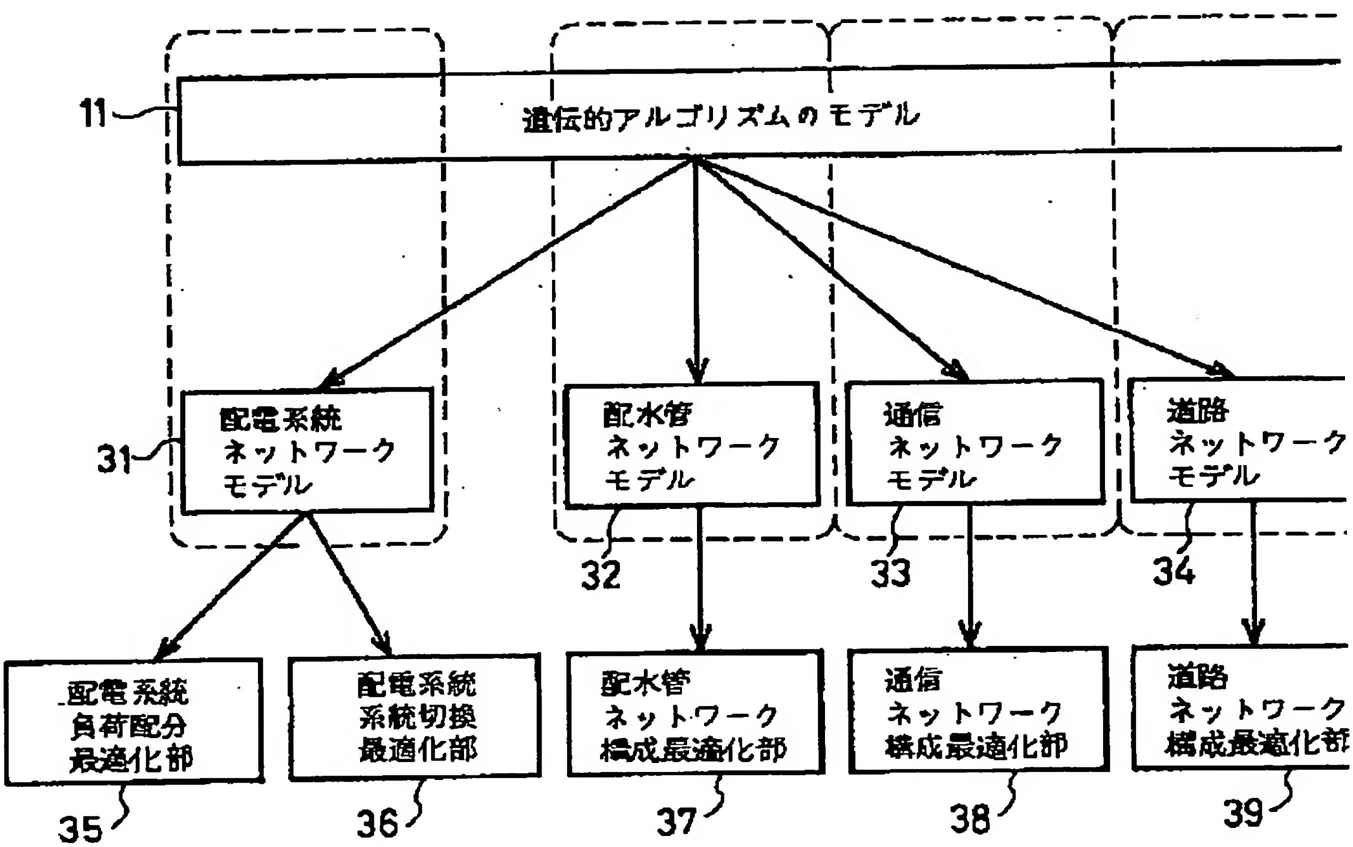
[Description of Notations]

11 Model of Genetic Algorithm
12 Model for Application
13 Gene Template Class
14 Gene Class
17 Node Class
18 Branch Class
22 Branch Class (Pipe Class)
23 Node Class
25 Branch Class (Line Class)
26 Node Class
28 Branch Class (Load Class)
29 Node Class (Intersection Class)
31 Power-Distribution-System Network Model
32 Distributing Water Pipe Network Model
33 Communication Link Network Model
34 Road Network Model

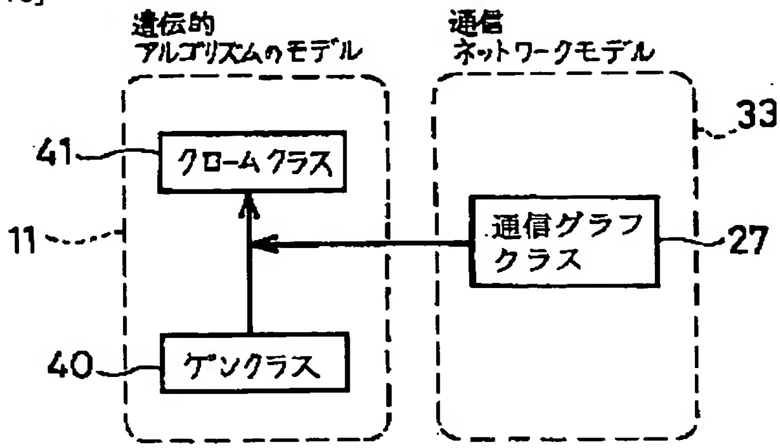
42, 43, 45-48 Node
44 Source Node
[Procedure amendment 2]
[Document to be Amended] DRAWINGS
[Item(s) to be Amended] drawing 3
[Method of Amendment] Modification
[Proposed Amendment]
[Drawing 3]



[Procedure amendment 3]
[Document to be Amended] DRAWINGS
[Item(s) to be Amended] drawing 7
[Method of Amendment] Modification
[Proposed Amendment]
[Drawing 7]



[Procedure amendment 4]
[Document to be Amended] DRAWINGS
[Item(s) to be Amended] drawing 10
[Method of Amendment] Modification
[Proposed Amendment]
[Drawing 10]



[Translation done.]

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(19)日本国特許庁（ＪＰ）　(12) **公開特許公報**（A）　(11)特許出願公開番号

特開平7－44519

(43)公開日　平成7年(1995)2月14日

(51)Int.Cl.⁶	識別記号	庁内整理番号	F I	技術表示箇所
G06F　15/18	550　C	8837－5L		
// G06F　9/44	550　R	9193－5B		

審査請求　未請求　請求項の数11　OL　（全 12 頁）

(21)出願番号　特願平5－192564

(22)出願日　平成5年(1993)8月3日

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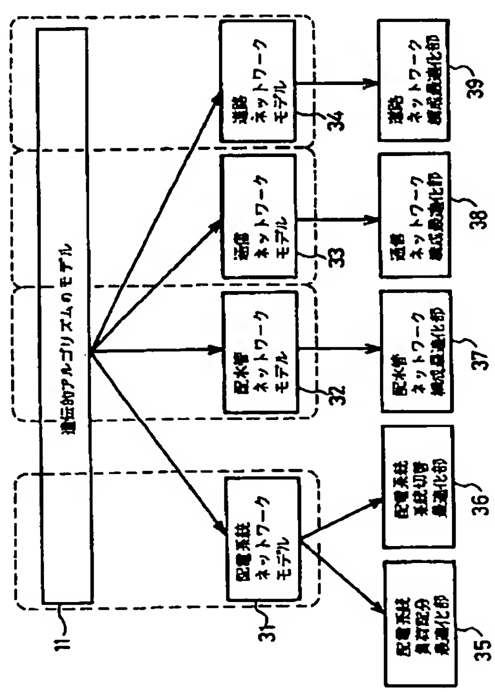
(54)【発明の名称】　遺伝的アルゴリズム実装方法、およびそれを用いたネットワーク最適化方法

(57)【要約】

【目的】　遺伝的アルゴリズムの適用、ネットワーク最適化のためのソフトウェア作成の効率化をはかる。

【構成】　オブジェクト指向設計を採用して構築した遺伝的アルゴリズムの汎用モデルを適用対象のモデルと組み合わせ、遺伝的アルゴリズムを適用対象のデータを含まない遺伝子テンプレートクラスと、それを含む遺伝子クラスで階層化することにより、両モデルのインタフェースを一括管理して独立性を高め、配電系統、配水管、通信網、道路網等のネットワークの柔軟なモデリング、当該モデルの変更への柔軟な対応を可能とし、また適用対象のモデルと最適化の評価関数を与えてそれらネットワークの最適化、放射状ネットワークの検索を可能とする。



【特許請求の範囲】

【請求項１】　対象を最適化する方法である遺伝的アルゴリズムを実装する遺伝的アルゴリズム実装方法において、オブジェクト指向設計を採用して、前記遺伝的アルゴリズムのモデルを、適用しようとする前記対象のデータを全く含まない遺伝子テンプレートクラスと、適用しようとする前記対象のデータを含んだサブクラスである遺伝子クラスを有する階層的なモデルとし、当該遺伝的アルゴリズムを適用しようとする前記対象のモデルと組み合わせることを特徴とする遺伝的アルゴリズム実装方法。

【請求項２】　適用しようとする前記対象を配電系統ネットワークとし、前記配電系統ネットワークの構成要素である電源ノードおよび負荷ノードをノードクラス、各ノード間の送電線をブランチクラスとして表現し、ネットワークをボトムアップに構築して、前記配電系統ネットワークを階層的にモデル化したことを特徴とする、請求項１に記載の遺伝的アルゴリズム実装方法。

【請求項３】　適用しようとする前記対象を配水管ネットワークとし、前記配水管ネットワークの構成要素である配水管をブランチクラス、分岐点をノードクラスとして表現し、ネットワークをボトムアップに構築して、前記配水管ネットワークを階層的にモデル化したことを特徴とする、請求項１に記載の遺伝的アルゴリズム実装方法。

【請求項４】　適用しようとする前記対象を通信ネットワークとし、前記通信ネットワークの構成要素である通信伝送路をブランチクラス、通信網ノードをノードクラスとして表現し、ネットワークをボトムアップに構築して、前記通信ネットワークを階層的にモデル化したことを特徴とする、請求項１に記載の遺伝的アルゴリズム実装方法。

【請求項５】　適用しようとする前記対象を道路ネットワークとし、前記道路ネットワークの構成要素である道路をブランチクラス、交差点をノードクラスとして表現し、ネットワークをボトムアップに構築して、前記道路ネットワークを階層的にモデル化したことを特徴とする、請求項１に記載の遺伝的アルゴリズム実装方法。

【請求項６】　請求項２に記載した発明の方法を用いて遺伝的アルゴリズムを実装した配電系統ネットワークの構成を最適化するネットワーク最適化方法において、前記配電系統ネットワークモデルの各電源ノードの電源の供給容量と、それに接続される負荷ノードの容量に基づいて定義された評価関数を最大とするように、前記負荷ノードの前記電源ノードへの割り当を行うことを特徴とするネットワーク最適化方法。

【請求項７】　請求項２に記載した発明の方法を用いて遺伝的アルゴリズムを実装した配電系統ネットワークの系統切換を最適化するネットワーク最適化方法において、前記配電系統ネットワークモデルの各送電線の容量に基づいて定義された評価関数を最小とするように、前記配電系統ネットワークの系統切換を行うことを特徴とするネットワーク最適化方法。

【請求項８】　請求項３に記載した発明の方法を用いて遺伝的アルゴリズムを実装した配水管ネットワークの構成を最適化するネットワーク最適化方法において、前記配水管ネットワークモデルの各配水管の容量に基づいて定義された評価関数を最小とするように、前記配水管の配置を行うことを特徴とするネットワーク最適化方法。

【請求項９】　請求項４に記載した発明の方法を用いて遺伝的アルゴリズムを実装した通信ネットワークの構成を最適化するネットワーク最適化方法において、前記通信ネットワークモデルの各通信伝送路の容量に基づいて定義した評価関数を最小とするように、前記通信伝送路の設置を行うことを特徴とするネットワーク最適化方法。

【請求項１０】　請求項５に記載した発明の方法を用いて遺伝的アルゴリズムを実装した道路ネットワークの構成を最適化するネットワーク最適化方法において、前記道路ネットワークモデルの各道路の容量に基づいて定義した評価関数を最小とするように、前記道路の配置を行うことを特徴とするネットワーク最適化方法。

【請求項１１】　放射状に構成されたネットワークを検索して遺伝的アルゴリズムを適用する遺伝的アルゴリズム実装方法において、前記放射状のネットワーク中の基準となるノードからの距離が等しいノードの中より選択したノードを、前記放射状のネットワークに追加することによって当該放射状のネットワークを検索することを特徴とする遺伝的アルゴリズム実装方法。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】この発明は、任意の対象を最適化する方法である遺伝的アルゴリズムをその対象に適用するための遺伝的アルゴリズム実装方法、およびその遺伝的アルゴリズム実装方法を用いたネットワーク最適化方法に関するものである。

【０００２】

【従来の技術】図１５は例えば、“遺伝的アルゴリズムの現状と課題”（小林重信　計測自動制御学会学会誌「計測と制御」第３２巻　第１号　第２～９頁　１９９３年　１月）に示された、任意の対象を最適化する方法である遺伝的アルゴリズムを示す概念図である。図において、１はある世代の遺伝子群による初期化の過程であり、２は遺伝子を複製して次世代の遺伝子群を形成する複製の過程である。３は遺伝子を組にしてその一部の入れ替えを行う交叉の過程であり、４は遺伝子の一部が交換される突然変異の過程である。

【０００３】次に動作について説明する。まず、このような遺伝的アルゴリズムによる対象の最適化について説明する。遺伝的アルゴリズムでは、最適化しようとする

適用対象を文字列等で表現してそれを遺伝子とみなし、複数の遺伝子について適正化を行う。この遺伝的アルゴリズムの一般的な手順は、図１５に示した初期化の過程１、複製の過程２、交叉の過程３、突然変異の過程４からなっている。即ち、初期化されたある世代の遺伝子群を模式的に表したものが図１５の１で、図中の円はそれぞれ遺伝子を示し、円内の模様がそれぞれの遺伝子の表現形を表している。次に、複製の過程２で遺伝子の複製を行って次世代の遺伝子を形成する。この遺伝子の複製に際しては、評価の高いものがより多く残るようにする。次に、交叉の過程３において遺伝子の交差が行われる。この遺伝子の交差は、遺伝子をランダムに組にしてお互いの一部を交換するものであり、こうすることによって、解の探索範囲が初期個体群よりも拡大される。次に、突然変異の過程４で遺伝子の突然変異を発生させる。この突然変異はある低い確率で遺伝子の１文字を交換することによって発生させるものであり、これによって局所解からの脱出を容易なものとする。このような初期化、複製、交叉、突然変異の各過程によるサイクルを繰り返すことにより、評価の高い遺伝子を得るものである。

【０００４】また、図１６は例えば、“事故時を考慮した配電系統設備増設計画”（奈良宏一　外２名　電気学会研究会資料　電力技術研究会　ＰＥ－９１－１１５　１９９１年　１０月）に示された従来の配電系統ネットワークのモデルを示す説明図である。この配電系統ネットワークのモデルでは、変電所、変圧器、負荷がノードとして、各ノード間のフィーダや送電線などかブランチとしてそれぞれ表現されている。図において、５はソースノード、６は変圧器ノード、７は変電所ノード、８は負荷ノードであり、９は新設フィーダ、１０は既設フィーダである。

【０００５】なお、このような適用の対象となるネットワークに遺伝的アルゴリズムを実装する場合、適用される対象に合わせてソフトウェアを構築することが必要で、前記複製、交叉、および突然変異の遺伝オペレータの実装を変更する場合にはソフトウェアを最初から作り直していた。また、遺伝的アルゴリズムの適用対象のモデルを構築する場合、モデルが大規模になるとその構成を全体として把握しにくくなり、大規模なモデルの構築には困難を伴うものであった。

【０００６】

【発明が解決しようとする課題】従来の遺伝的アルゴリズムは以上のように構成されているので、汎用性に乏しく、それを対象となるネットワークに適用する際には、対象のモデリングやモデル変更への対応に柔軟性を欠くため、ソフトウェアの作成効率が低く、また、ネットワークの最適化にも困難を伴うなどの問題点があった。

【０００７】この発明は上記のような問題点を解消するためになされたもので、請求項１に記載の発明は、再利用性の高い汎用的な遺伝的アルゴリズムのモデルの構築を可能として、ソフトウェア作成の効率化がはかれる遺伝的アルゴリズム実装方法を得ることを目的とする。

【０００８】また、請求項２～５に記載の発明は、適用対象であるネットワークの柔軟なモデリングが可能になるとともに、モデルの変更にも柔軟に対応できる遺伝的アルゴリズム実装方法を得ることを目的とする。

【０００９】また、請求項６～１０に記載の発明は、ネットワークを容易に最適化できるネットワーク最適化方法を得ることを目的とする。

【００１０】また、請求項１１に記載の発明は、遺伝的アルゴリズムにおける初期解の生成の効率化が可能な遺伝的アルゴリズム実装方法を得ることを目的とする。

【００１１】

【課題を解決するための手段】請求項１に記載の発明に係る遺伝的アルゴリズム実装方法は、オブジェクト指向設計を採用することによって、遺伝的アルゴリズムのモデルを適用対象のデータを全く含まない遺伝子テンプレートクラスと、それを含んだ遺伝子クラスを有する階層構造として、それを適用対象のモデルと組み合わせたものである。

【００１２】また、請求項２に記載の発明に係る遺伝的アルゴリズム実装方法は、適用対象の配電系統ネットワークの電源ノード、負荷ノード、送電線をノードクラスまたはブランチクラスとして表現し、配電系統ネットワークをボトムアップに構築して階層的にモデル化したものである。

【００１３】また、請求項３に記載の発明に係る遺伝的アルゴリズム実装方法は、適用対象の配水管ネットワークの配水管、分岐点をブランチクラスまたはノードクラスとして表現し、配水管ネットワークをボトムアップに構築して階層的にモデル化したものである。

【００１４】また、請求項４に記載の発明に係る遺伝的アルゴリズム実装方法は、適用対象の通信ネットワークの通信伝送路、通信網ノードをブランチクラスまたはノードクラスとして表現し、通信ネットワークをボトムアップに構築して階層的にモデル化したものである。

【００１５】また、請求項５に記載の発明に係る遺伝的アルゴリズム実装方法は、適用対象の道路ネットワークの道路、交差点をブランチクラスまたはノードクラスとして表現し、道路ネットワークをボトムアップに構築して階層的にモデル化したものである。

【００１６】また、請求項６に記載の発明に係るネットワーク最適化方法は、請求項２に記載の方法で遺伝的アルゴリズムを実装した配電系統ネットワークについて、その各電源ノードの電源供給容量とそれに接続される負荷ノードの容量に基づいて評価関数を定義し、それが最大となるように負荷ノードの電源ノードへの割り当を行うものである。

【００１７】また、請求項７に記載の発明に係るネット

ワーク最適化方法は、請求項２に記載の方法で遺伝的アルゴリズムを実装した配電系統ネットワークについて、その各送電線の容量に基づいて評価関数を定義し、それが最小となるように配電系統ネットワークの系統切換を行うものである。

【００１８】また、請求項８に記載の発明に係るネットワーク最適化方法は、請求項３に記載の方法で遺伝的アルゴリズムを実装した配水管ネットワークについて、その各配水管の容量に基づいて評価関数を定義し、それが最小となるように配水管の配置を行うものである。

【００１９】また、請求項９に記載の発明に係るネットワーク最適化方法は、請求項４に記載の方法で遺伝的アルゴリズムを実装した通信ネットワークについて、その各通信伝送路の容量に基づいて評価関数を定義し、それが最小となるように通信伝送路の設置を行うものである。

【００２０】また、請求項１０に記載の発明に係るネットワーク最適化方法は、請求項５に記載の方法で遺伝的アルゴリズムを実装した道路ネットワークについて、その各道路の容量に基づいて評価関数を定義し、それが最小となるように道路の配置を行うものである。

【００２１】また、請求項１１に記載の発明に係る遺伝的アルゴリズム実装方法は、放射状に構成されたネットワーク中の基準となるノードからの距離が等しいノードの中からランダムにノードを選択し、それをそのネットワークに追加してゆくことにより当該放射状ネットワークを検索するものである。

【００２２】

【作用】請求項１に記載の発明における遺伝的アルゴリズム実装方法は、遺伝的アルゴリズムのモデルをオブジェクト指向設計を採用して実装することにより、適用対象のデータを全く含まない遺伝子テンプレートクラスと、それを含んだ遺伝子クラスを用いて、適用しようとする対象に依存しない汎用性の高い遺伝的アルゴリズムとし、ソフトウェアの生成を効率的なものとする。

【００２３】また、請求項２に記載の発明における遺伝的アルゴリズム実装方法は、構成要素である電源ノードと負荷ノードをノードクラス、送電線をブランチクラスとして表現することにより、配電系統ネットワークをボトムアップに構築して階層的にモデル化する。

【００２４】また、請求項３に記載の発明における遺伝的アルゴリズム適用方法は、構成要素である配水管をブランチクラス、分岐点をノードクラスとして表現することにより、配水管ネットワークをボトムアップに構築して階層的にモデル化する。

【００２５】また、請求項４に記載の発明における遺伝的アルゴリズム適用方法は、構成要素である通信伝送路をブランチクラス、通信網ノードをノードクラスとして表現することにより、通信ネットワークをボトムアップに構築して階層的にモデル化する。

【００２６】また、請求項５に記載の発明における遺伝的アルゴリズム適用方法は、構成要素である道路をブランチクラス、交差点をノードクラスとして表現することにより、道路ネットワークをボトムアップに構築して階層的にモデル化する。

【００２７】また、請求項６に記載の発明におけるネットワーク最適化方法は、各電源ノードの電源の供給容量と、それに接続される負荷ノードの容量に基づいて定義した評価関数が最大となるように、負荷ノードの電源ノードへの割り当を行うことにより、請求項２に記載した発明の方法を用いて遺伝的アルゴリズムを実装した配電系統ネットワークの構成を最適化する。

【００２８】また、請求項７に記載の発明におけるネットワーク最適化方法は、各送電線の容量に基づいて定義した評価関数が最小となるように、配電系統ネットワークの系統切換を行うことにより、請求項２に記載した発明の方法で遺伝的アルゴリズムを適用した配電系統ネットワークの系統切換を最適化する。

【００２９】また、請求項８に記載の発明におけるネットワーク最適化方法は、各配水管の容量に基づいて定義した評価関数が最小となるように、配水管の配置を行うことにより、請求項３に記載した発明の方法で遺伝的アルゴリズムを適用した配水管ネットワークの構成を最適化する。

【００３０】また、請求項９に記載の発明におけるネットワーク最適化方法は、各通信伝送路の容量に基づいて定義した評価関数が最小となるように、通信伝送路の設置を行うことにより、請求項４に記載した発明の方法で遺伝的アルゴリズムを適用した通信ネットワークの構成を最適化する。

【００３１】また、請求項１０に記載の発明におけるネットワーク最適化方法は、各道路の容量に基づいて定義した評価関数が最小となるように道路の配置を行うことにより、請求項５に記載した発明の方法で遺伝的アルゴリズムを適用した道路ネットワークの構成を最適化する。

【００３２】また、請求項１１に記載の発明における遺伝的アルゴリズム実装方法は、放射状に構成されたネットワーク中の基準となるノードからの距離が等しいノードの中からランダムに選択したノードをそのネットワークに追加し、当該放射状ネットワークを検索することにより、遺伝的アルゴリズムにおける初期解を効率的に生成する。

【００３３】

【実施例】

実施例１．以下、この発明の実施例１を図について説明する。図１は請求項１に記載の発明の一実施例による遺伝的アルゴリズム実装方法を示す概念図である。図において、１１は遺伝的アルゴリズムのモデルであり、１２はこの遺伝的アルゴリズムが適用される適用対象のモデ

ルである。なお、この遺伝的アルゴリズムのモデル１１で適用対象のデータとして必要なものは遺伝子の遺伝子型のみであり、適用対象のモデル１２で必要なものは遺伝子の表現型のみである。従って、それらを遺伝的アルゴリズムのモデル１１と適用対象のモデル１２の間のインタフェースとして分離して構築する。

【００３４】また、図２は遺伝的アルゴリズムのクラス階層を示す概念図である。図において、１３は当該遺伝的アルゴリズムの最下位にある遺伝子テンプレートクラスであり、１４はこの遺伝子テンプレートクラス１３を継承したサブクラスとしての遺伝子クラスである。１５はこの遺伝子クラス１４の上位にあって遺伝子クラス１４をメンバにもつ個体群クラスであり、１６はこの個体群クラス１５の上位にあって、個体群クラス１５をメンバにもつアプリケーションクラスである。

【００３５】次に動作について説明する。なお、遺伝子テンプレートクラス１３には適用対象の情報は全く含まれておらず、遺伝オペレータも宣言のみで実装されてはいない。遺伝子クラス１４は適用対象の情報を含み、遺伝オペレータもここで実装される。従って、遺伝子クラス１４より上の階層のクラスから見ると、メンバや遺伝オペレータなどのメンバ関数は、適用対象のデータの影響を受けることはない。例えば、遺伝オペレータの１つである「複製」を示すメンバ関数を“reproduce ”とすると、遺伝子テンプレートクラス１３で“reproduce ”は空の関数であり、遺伝子クラス１４で実際の内容が記述される。遺伝子クラス１４より上のクラスでは、「複製」を示す関数を“reproduce ”と記述しておけば、適用対象に関わらず遺伝的アルゴリズムのモデル１１を変更する必要はない。

【００３６】このように、この実施例１による遺伝的アルゴリズム実装方法では、遺伝子クラス１４を抽象データ型とし、適用対象の情報やそれに合わせた遺伝オペレータの実装をそのサブクラスで行うことにより、適用対象とのインタフェースをより少ないものとする。

【００３７】実施例２．次に、この発明の実施例２を図について説明する。図３は請求項２に記載の発明の一実施例による配電系統ネットワークのクラス階層を示す概念図である。図において、１７は電源ノードと負荷ノードを表現するノードクラスであり、１８はノード間を接続する送電線などのブランチを表現するブランチクラスである。１９は複数のノードと複数のブランチで構成されるネットワークの基底となるグラフクラスであり、２０は系統全体を表現するネットワーククラス、２１は電源ノードの供給エリアを表現するツリークラスである。このように、配電系統ネットワークのモデルをノードクラス１７、ブランチクラス１８、グラフクラス１９、ネットワーククラス２０、およびツリークラス２１による階層構造に構築することにより、大規模なモデリングが容易なものとなり、また仕様変更にも柔軟に対応することが可能となる。

【００３８】実施例３．次に、この発明の実施例３を図について説明する。図４は請求項３に記載の発明の一実施例による配水管ネットワークのクラス階層を示す概念図である。図において、２２は配水管を表現するブランチクラスとしてのパイプクラス、２３は分岐点を表現するノードクラスであり、２４はこの配水管ネットワークの基底となるウォータグラフクラスである。このように、配水管ネットワークのモデルをパイプクラス２２、ノードクラス２３、およびウォータグラフクラス２４による階層構造に構築することにより、大規模なモデリングが容易なものとなり、また仕様変更にも柔軟に対応することが可能となる。

【００３９】実施例４．次に、この発明の実施例４を図について説明する。図５は請求項４に記載の発明の一実施例による通信ネットワークのクラス階層を示す概念図である。図において、２５は通信伝送路を表現するブランチクラスとしてのラインクラス、２６は通信網ノードを表現するノードクラスであり、２７はこの通信ネットワークの基底となる通信グラフクラスである。このように、配水管ネットワークのモデルをラインクラス２５、ノードクラス２６、および通信グラフクラス２７による階層構造に構築することにより、大規模なモデリングが容易なものとなり、また仕様変更にも柔軟に対応することが可能となる。

【００４０】実施例５．次に、この発明の実施例５を図について説明する。図６は請求項５に記載の発明の一実施例による道路ネットワークのクラス階層を示す概念図である。図において、２８は道路を表現するブランチクラスとしてのロードクラス、２９は交差点を表現するノードクラスとしてのインターセクションクラスであり、３０はこの道路ネットワークの基底となるロードグラフクラスである。このように、道路ネットワークのモデルをロードクラス２８、インターセクションクラス２９、およびロードグラフクラス３０による階層構造に構築することにより、大規模なモデリングが容易なものとなり、また仕様変更にも柔軟に対応することが可能となる。

【００４１】実施例６．次に、この発明の実施例６を図について説明する。ここで、図７はこの実施例５および以下に説明する実施例６～１０によるネットワーク適正化方法を説明するための概念図である。図において、１１は図１で説明した遺伝的アルゴリズムのモデルであり、３１はその遺伝的アルゴリズムの適用対象を配電系統ネットワークとした場合の適用対象のモデル１２としての配電系統ネットワークモデルである。３２は同じく適用対象を配水管ネットワークとした場合の配水管ネットワークモデルであり、３３は適用対象を通信ネットワークとした場合の通信ネットワークモデル、３４は適用対象を道路ネットワークとした場合の道路ネットワーク

モデルである。また、３５は配電系統ネットワークモデル３１による配電系統ネットワークの構成を最適化する配電系統負荷配分最適化部であり、３６はその配電系統ネットワークの系統の切換を最適化する配電系統系統切換最適化部である。３７は配水管ネットワークモデル３２による配水管ネットワークの構成を最適化する配水管ネットワーク構成最適化部であり、３８は通信ネットワークモデル３３による通信ネットワークの構成を最適化する通信ネットワーク構成最適化部、３９は道路ネットワークモデル３４による道路ネットワークの構成を最適化する道路ネットワーク構成最適化部である。

【００４２】図７に示すように、あらかじめ汎用性のある遺伝的アルゴリズムのモデル１１を作っておいて、配電系統ネットワークなどの適用対象についてその遺伝的アルゴリズムを適用する場合、その配電系統ネットワーク等の適用対象のモデル３１～３４を遺伝的アルゴリズムのモデル１１とは独立に作り、それら２つのモデルを、モデル１１と３１、１１と３２、１１と３３、あるいは１１と３４のように組み合わせると、その対象および目的に応じた最適化のためのソフトウェアが完成する。

【００４３】図８は請求項６に記載の発明の一実施例を説明するための、遺伝的アルゴリズムのモデル１１と配電系統ネットワークモデル３１との間のインタフェースを示す概念図である。図において、４０は遺伝子を表す抽象クラスで、それ自身はインタフェースを持たないゲン（Gene）クラスであり、４１は配電系統ネットワークモデル３１のクラス（例えば＃１～＃ｎツリークラス２１）がメンバとして実装されるクローム（Chrom ）クラスである。ゲンクラス４０は適用対象である配電系統ネットワークについてのデータは全く持ち合わせておらず、配電系統ネットワークモデル３１の＃１～＃ｎツリークラス２１が、後述するようにクロームクラス４１のメンバとして実装される。これによって遺伝オペレータ中で適用対象モデルである配電系統ネットワークモデル３１に対してアクセスすることが可能となる。また、ゲンクラス４０は交叉などの遺伝オペレータをメンバ関数とするが、ここでは空の関数として定義され、実際の実装はクロームクラス４１で行われる。

【００４４】次に、この発明における遺伝的アルゴリズムの実装方法を図９のフローチャートにしたがって説明する。まず、ステップＳＴ１にて遺伝的アルゴリズムのモデル１１における遺伝子クラス１４のプロトタイプの実装を行う。その後、ステップＳＴ２で配電系統ネットワーク等の適用対象のモデル１２を作成し、次にステップＳＴ３において、その情報を考慮した遺伝子クラス１４の実装を行って処理を終了する。

【００４５】以下、図７に示した配電系統負荷配分適正化部３５による、配電系統ネットワークの構成を適正化する方法について説明する。なお、ここでは、配電系統ネットワークの各負荷ノードを、電源ノードの容量を越えないように電源ノードに割り当てる場合について説明する。配電系統負荷配分適正化部３５では最適化のための評価関数Ｆを次の（１）式のように定義する。

【００４６】

【数１】

$$F=\sum_{i=1}^{P_{max}} f\left(\sum_{j=1}^{\ell_{max}} L_{ij}\ ,\ P_i\right) \quad \cdots\cdots (1)$$

【００４７】なお、上記（１）式中のｉ，ｊ，Ｐｉ，Ｌｉｊはそれぞれ次のものを示す。

ｉ　：電源ノードの番号（$1 \leqq i \leqq p_{max}$）

ｊ　：負荷ノードの番号（$1 \leqq j \leqq l_{max}$）

P_i：番号ｉの電源ノードの容量

L_{ij}：番号ｉの電源ノードに接続する番号ｊの負荷ノードの容量

【００４８】また、上記（１）式内の関数ｆは次の（２）式で与えられる。

【００４９】

【数２】

$$f(x,\ y)=\begin{cases} x\ ;\ x \leqq y \\ 0\ ;\ x > y \end{cases} \quad \cdots\cdots (2)$$

【００５０】ここで、この評価関数Ｆは、各電源ノードについて、供給余裕が大きい方か望ましいことを示している。配電系統負荷分配適正化部３５はこの評価関数Ｆが最大となるように負荷ノードの電源ノードへの割り当を行うことにより、配電系統ネットワークの構成を最適化する。

【００５１】実施例７．次に、この発明の実施例７について説明する。この実施例７は請求項７に記載した発明の一実施例であり、遺伝的アルゴリズムのモデル１１と配電系統ネットワークモデル３１との間のインタフェースは、実施例６の場合と同様に図８に示すように実装される。

【００５２】以下、図７に示した配電系統系統切換適正化部３６による、配電系統ネットワークの系統切換を適正化する方法について説明する。なお、ここでは、電源ノードと負荷ノードが与えられた時に、送電線の最大容量が最小となるように系統の切換を行う場合について説明する。配電系統系統切換適正化部３６では最適化のた

めの評価関数Ｆを次の（３）式のように定義する。
【００５３】
【数３】

$$F=\max_{i}\{\ CP_i\ \}\qquad\cdots\cdots(3)$$

【００５４】なお、上記（３）式中のｉとＣＰｉはそれぞれ次のものを示す。
ｉ　　：送電線の番号
CP_i：番号ｉの送電線の容量
【００５５】配電系統系統切換適正化部３６はこの評価関数Ｆが最小となるように配電系統ネットワークの系統切換を行うことにより、配電系統ネットワークの系統切換を最適化する。
【００５６】実施例８．次に、この発明の実施例８を図について説明する。図１０は請求項８に記載の発明の一実施例による、遺伝的アルゴリズムのモデル１１と配水管ネットワークモデル３２との間のインタフェースを示す概念図である。この場合、遺伝的アルゴリズムのモデル１１のクロームクラス４１には、配水管ネットワークモデル３２のウォータグラフクラス２４がメンバとして実装される。
【００５７】以下、図７に示した配水管ネットワーク適正化部３７による、配水管ネットワークの構成を適正化する方法について説明する。なお、ここでは、水の供給箇所と消費箇所が与えられた時に、配水管の最大容量が最小となるように配水管の配置を行う場合について説明する。配水管ネットワーク適正化部３７では、最適化のための評価関数Ｆを次の（４）式のように定義する。
【００５８】
【数４】

$$F=\max_{i}\{\ CW_i\ \}\qquad\cdots\cdots(4)$$

【００５９】なお、上記（４）式中のｉとＣＷｉはそれぞれ次のものを示す。
ｉ　　：配水管の番号
CW_i：番号ｉの配水管の容量
【００６０】配水管ネットワーク適正化部３７はこの評価関数Ｆが最小となるように配水管の配置を行うことにより、配水管ネットワークの構成を最適化する。
【００６１】実施例９．次に、この発明の実施例９を図について説明する。図１１は請求項９に記載の発明の一実施例による、遺伝的アルゴリズムのモデル１１と通信ネットワークモデル３３との間のインタフェースを示す概念図である。この場合、遺伝的アルゴリズムのモデル１１のクロームクラス４１には、通信ネットワークモデル３３の通信グラフクラス２７がメンバとして実装される。
【００６２】以下、図７に示した通信ネットワーク適正化部３８による、通信ネットワークの構成を適正化する方法について説明する。なお、ここでは、信号の発信箇所と中継箇所が与えられた時に、通信伝送路の最大容量が最小となるように通信伝送路の設置を行う場合について説明する。通信ネットワーク適正化部３８では、最適化のための評価関数Ｆを次の（５）式のように定義する。
【００６３】
【数５】

$$F=\max_{i}\{\ CC_i\ \}\qquad\cdots\cdots(5)$$

【００６４】なお、上記（５）式中のｉとＣＣｉはそれぞれ次のものを示す。
ｉ　　：通信伝送路の番号
CC_i：番号ｉの通信伝送路の容量
【００６５】通信ネットワーク適正化部３８はこの評価関数Ｆが最小となるように通信伝送路の設定を行うことにより、通信ネットワークの構成を最適化する。
【００６６】実施例１０．次に、この発明の実施例１０を図について説明する。図１２は請求項１０に記載の発明の一実施例による、遺伝的アルゴリズムのモデル１１と道路ネットワークモデル３４の間のインタフェースを示す概念図である。この場合、遺伝的アルゴリズムのモデル１１のクロームクラス４１には、道路ネットワークモデル３４のロードグラフクラス３０がメンバとして実装される。
【００６７】以下、図７に示した道路ネットワーク適正化部３９による、道路ネットワークの構成を適正化する方法について説明する。なお、ここでは、道路の交差点が与えられた時に、道路の最大容量が最小となるように道路の配置を行う場合について説明する。道路ネットワーク適正化部３９では、最適化のための評価関数Ｆを次の（６）式のように定義する。
【００６８】
【数６】

$$F=\max_{i}\{\ CR_i\ \}\qquad\cdots\cdots(6)$$

【００６９】なお、上記（６）式中のｉとＣＲｉはそれぞれ次のものを示す。
ｉ　　：道路の番号
CR_i：番号ｉの道路の容量

【0070】道路ネットワーク適正化部39はこの評価関数Fが最小となるように道路の配置を行うことにより、道路ネットワークの構成を最適化する。

【0071】実施例11．次に、この発明の実施例11を図について説明する。図13は請求項11に記載した発明の一実施例における放射状ネットワークの検索過程を示す概念図である。図において、42は放射状ネットワーク中の基準となるノードであり、43はこのノード42から等距離にあるノードである。まず、放射状ネットワーク枝のノードを1つ取り上げてそれを基準となるノード42とする。次に、この基準となるノード42からの距離が等しいノード43のうち、まだネットワークに含まれていないノードを考える。そのようなノード43が、例えば図13に示すように3つあるとすると、その3つのノード43の中から1つ、2つ、3つのノード43をランダムに選択した場合を想定する。1つのノードを選択する場合を取り上げると、3つあるノード43の中から1つを選択する選び方には3通りあるので、それぞれの場合について、選択したノード43その放射状ネットワークに加える。このような過程を繰り返すことによって、当該放射状ネットワークを検索を行う。

【0072】また、図14はこの実施例11における放射状ネットワークの生成方法を示す概念図である。図において、44はソースノードであり、45はこのソースノード44に隣接したノード、46，47，48はこのノード45に隣接したノードである。ソースノード44から放射状ネットワークを構成する場合には、まずソースノード44に隣接したノード45をネットワークに付け加える。次に、このノード45に隣接しているノードはノード46，47および48の3つであるから、この3つのノード46～48の中から任意の個数、任意のノードをランダムに選択する。例えば、ノード46とノード47の2つを選んで、それをネットワークに付け加える。以下、これらノード46，47に隣接するノードについて同様の過程で順次、ノードを加えてゆくことで放射状ネットワークをランダムに生成する。

【0073】

【発明の効果】以上のように、請求項1に記載の発明によれば、オブジェクト指向設計を用いて、遺伝的アルゴリズムのモデルを適用対象のデータを全く含まない遺伝子テンプレートクラスと、それを含んだ遺伝子クラスを有する汎用モデルとし、その遺伝的アルゴリズムのモデルを、適用対象のモデルと組み合わせるように構成したので、適用しようとする対象に依存せずに汎用的に遺伝的アルゴリズムを適用することが可能となり、遺伝的アルゴリズムのモデルと適用対象のモデルの間のインタフェースも少なくすることとができて、ソフトウェアを効率的に生成できる効果がある。

【0074】また、請求項2に記載の発明によれば、配電系統ネットワークの構成要素である電源ノードと負荷ノードをノードクラス、送電線をブランチクラスとして表現し、ネットワークをボトムアップに構築して階層的にモデル化するように構成したので、配電系統ネットワークの柔軟なモデリングが可能となって、モデルの変更にも柔軟に対応することができ、さらに大規模なモデリングも容易となる効果がある。

【0075】また、請求項3に記載の発明によれば、配水管ネットワークの構成要素である配水管をブランチクラス、分岐点をノードクラスとして表現し、ネットワークをボトムアップに構築して階層的にモデル化するように構成したので、配水管ネットワークの柔軟なモデリングが可能となって、モデルの変更にも柔軟に対応することができ、さらに大規模なモデリングも容易となる効果がある。

【0076】また、請求項4に記載の発明によれば、通信ネットワークの構成要素である通信伝送路をブランチクラス、通信網ノードをノードクラスとして表現し、ネットワークをボトムアップに構築して階層的にモデル化するように構成したので、通信ネットワークの柔軟なモデリングが可能となって、モデルの変更にも柔軟に対応することができ、さらに大規模なモデリングも容易となる効果がある。

【0077】また、請求項5に記載の発明によれば、道路ネットワークの構成要素である道路をブランチクラス、交差点をノードクラスとして表現し、ネットワークをボトムアップに構築して階層的にモデル化するように構成したので、道路ネットワークの柔軟なモデリングが可能となって、モデルの変更にも柔軟に対応することができ、さらに大規模なモデリングも容易となる効果がある。

【0078】また、請求項6に記載の発明によれば、各電源ノードの電源の供給容量と、それに接続される負荷ノードの容量に基づいて評価関数を定義し、それが最大となるように負荷ノードの電源ノードへの割り当てを行うように構成したので、請求項2に記載した発明の方法で遺伝的アルゴリズムを実装した配電系統ネットワークの構成を最適化することができる効果がある。

【0079】また、請求項7に記載の発明によれば、各送電線の容量に基づいて評価関数を定義し、それが最小となるように配電系統ネットワークの系統切換を行うように構成したので、請求項2に記載した発明の方法で遺伝的アルゴリズムを適用した配電系統ネットワークの系統切換を最適化することができる効果がある。

【0080】また、請求項8に記載の発明によれば、各配水管の容量に基づいて評価関数を定義し、それが最小となるように配水管の配置を行うように構成したので、請求項3に記載した発明の方法で遺伝的アルゴリズムを適用した配水管ネットワークの構成を最適化することができる効果がある。

【0081】また、請求項9に記載の発明によれば、各

通信伝送路の容量に基づいて評価関数を定義し、それが最小となするように通信伝送路の設置を行うように構成したので、請求項４に記載した発明の方法で遺伝的アルゴリズムを適用した通信ネットワークの構成を最適化することができる効果がある。

【００８２】また、請求項１０に記載の発明におけよれば、各道路の容量に基づいて評価関数を定義し、それが最小となるように道路の配置を行うように構成したので、請求項５に記載した発明の方法で遺伝的アルゴリズムを適用した道路ネットワークの構成を最適化することができる効果がある。

【００８３】また、請求項１１に記載の発明によれば、放射状に構成されたネットワーク中の基準となるノードから同一距離のノードの中からランダムに選択したノードをそのネットワークに追加するように構成したので、放射状ネットワークの検索が可能となって、遺伝的アルゴリズムにおける初期解を効率的に生成することができる効果がある。

【図面の簡単な説明】

【図１】この発明の実施例１による遺伝的アルゴリズム実装方法を示す概念図である。

【図２】上記実施例における遺伝的アルゴリズムのクラス階層を示す概念図である。

【図３】この発明の実施例２による遺伝的アルゴリズム実装方法を示す概念図である。

【図４】この発明の実施例３による遺伝的アルゴリズム実装方法を示す概念図である。

【図５】この発明の実施例４による遺伝的アルゴリズム実装方法を示す概念図である。

【図６】この発明の実施例５による遺伝的アルゴリズム実装方法を示す概念図である。

【図７】この発明の実施例６～１０によるネットワーク最適化方法を説明するための概念図である。

【図８】上記実施例６および７における遺伝的アルゴリズムのモデルと適用対象のモデルの間のインタフェースを示す概念図である。

【図９】上記実施例６～１０における遺伝的アルゴリズムの適用方法を示すフローチャートである。

【図１０】この発明の実施例８による遺伝的アルゴリズムのモデルと適用対象のモデルの間のインタフェースを示す概念図である。

【図１１】この発明の実施例９による遺伝的アルゴリズムのモデルと適用対象のモデルの間のインタフェースを示す概念図である。

【図１２】この発明の実施例１０による遺伝的アルゴリズムのモデルと適用対象のモデルの間のインタフェースを示す概念図である。

【図１３】この発明の実施例１１における放射状ネットワークの検索方法を示す概念図である。

【図１４】上記実施例における放射状ネットワークの構成方法を示す概念図である。

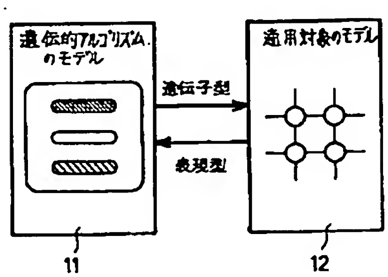
【図１５】従来の遺伝的アルゴリズムの枠組みを示す概念図である。

【図１６】従来の配電系統ネットワークの一例を示す説明図である。

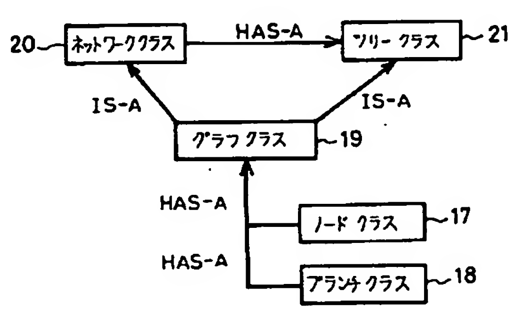
【符号の説明】

１１　遺伝的アルゴリズムのモデル
１２　適用対象のモデル
１３　遺伝子テンプレートクラス
１４　遺伝子クラス
１７　ノードクラス
１８　ブランチクラス
２２　ブランチクラス（パイプクラス）
２３　ノードクラス
２５　ブランチクラス（ラインクラス）
２６　ノードクラス
２８　ブランチクラス（ロードクラス）
２９　ノードクラス（インターセクションクラス）
３１　配電系統ネットワークモデル
３２　配水管ネットワークモデル
３３　通信ネットワークモデル
３４　道路ネットワークモデル
４２，４３，４５～４８　ノード
４４　ソースノード

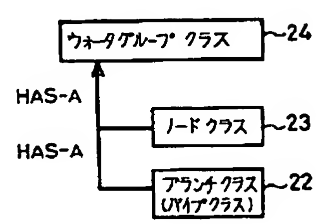
【図１】



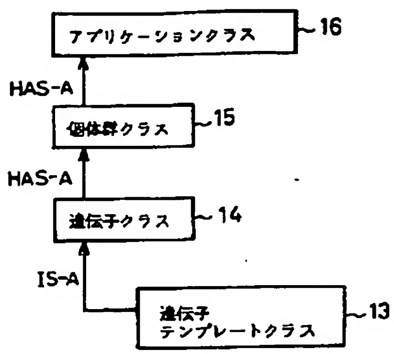
【図３】



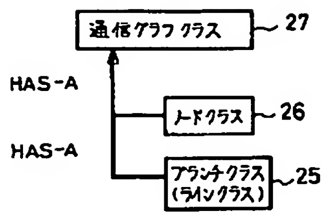
【図４】



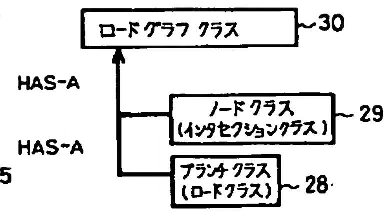
【図２】



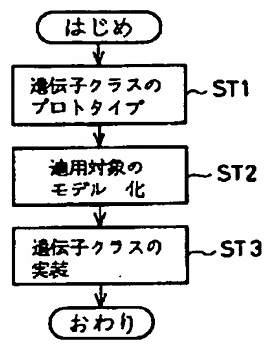
【図５】



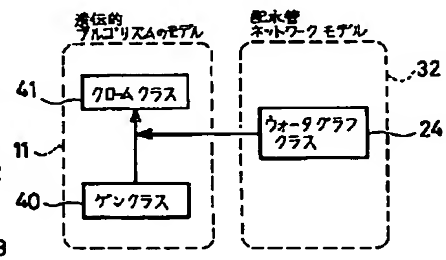
【図６】



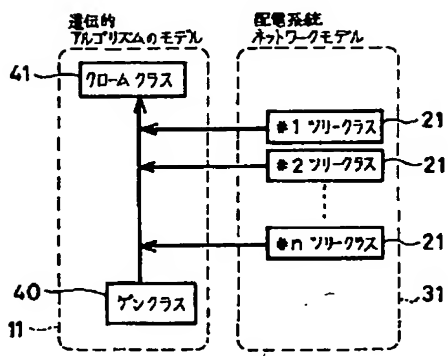
【図９】



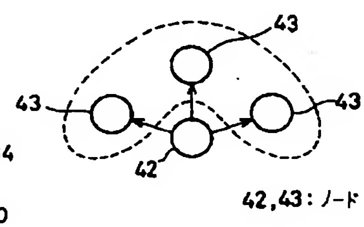
【図１０】



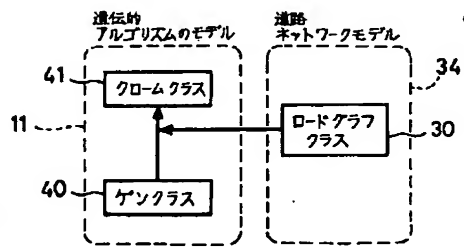
【図８】



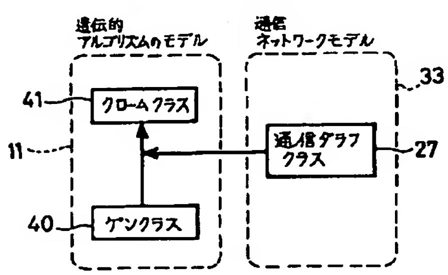
【図１３】



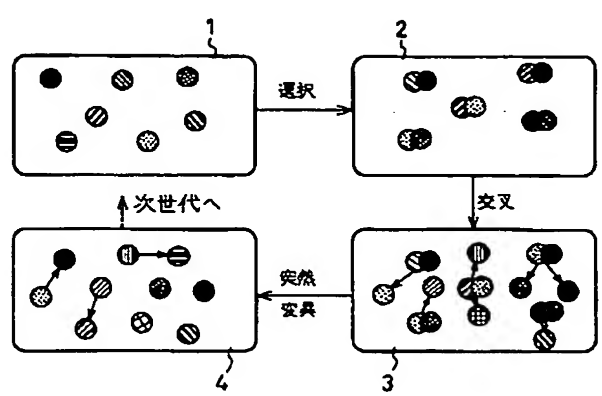
【図１２】



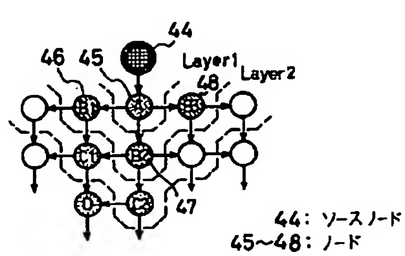
【図１１】



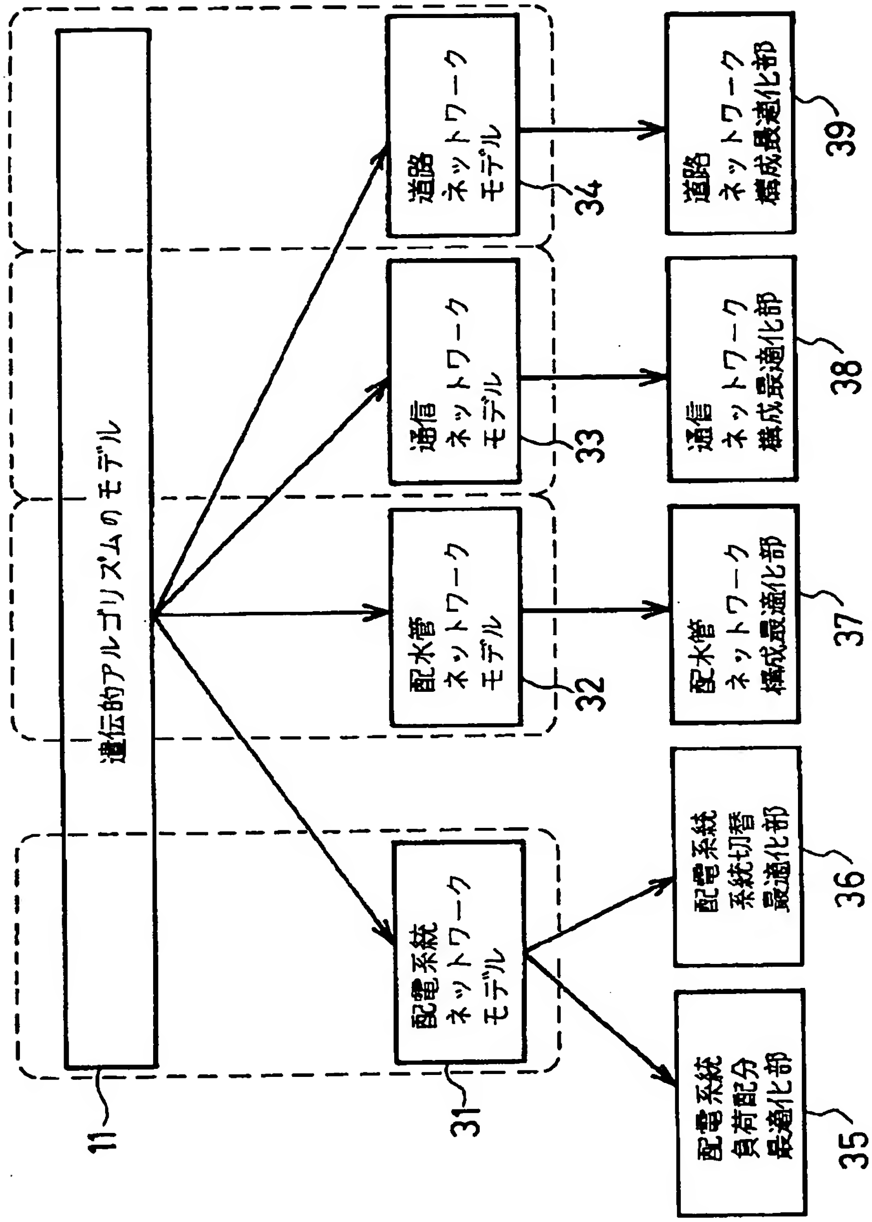
【図１５】



【図１４】



【図7】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【図１６】